Our ref.: 192128M

January 05, 2023

Carol Dye
UIC Director
Texas Commission on Environmental Quality
12100 Park 35 Circle Building F
Austin, Texas 78753

Subject: Permit Application Class I Nonhazardous Injection Well – North Texas Industrial Facility, Itasca, Hill County, Texas

Dear Ms. Dye:

On behalf of Republic Industrial and Energy Solutions, LLC (Republic), WSP USA, is submitting an application for Class I Nonhazardous Injection well at its North Texas Industrial Facility located in Itasca, Texas for your review.

The following information is enclosed:

- One original, two copies of the permit application
- One digital version of the permit application
- Documentation of the application fee payment sent to the TCEQ Financial Administration Division
- Permit Application Form (TCEQ-0623 UIC Class I Injection Well Application, November 2022 Revision)
- Updated Core data form (Attachment A)

If you need additional information, please do not hesitate to contact Gary McCuistion of Republic at 832-399-4516 (GMcCuistion@republicservices.com) or me at 225-508-3861 (morgan.canezaro@wsp.com).

Kind regards,

Morgan E Canezaro

Morgan Canezaro
Project Manager, UIC Lead

Encl.
cc: Gary McCuistion (Republic)

WSP USA
Suite 200
16200 Park Row
Houston, TX 77084

Tel.: +1 281 589-5900
Fax: +1 281 759-5164
wsp.com

UIC CLASS I INJECTION WELL PERMIT APPLICATION

COMMERCIAL NON-HAZARDOUS CLASS I INJECTION WELL, NORTH TEXAS INDUSTRIAL FACILITY, ITASCA HILL COUNTY, TEXAS

REPUBLIC INDUSTRIAL & ENERGY SOLUTIONS LLC

PROJECT NO.: 192128M
ORIGINAL: DECEMBER 2023
REVISION 1: MAY 2024

WSP
16200 PARK ROW, SUITE 200
HOUSTON, TX 77084

PHONE: 281-589-5900

WSP.COM

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I. TCEQ-00623 UIC CLASS I INJECTION WELL APPLICATION

I. General Information

A. Type of Application (check all that apply):

- ☒ Initial
- ☐ Renewal
- ☐ Major Amendment
- ☐ Minor Amendment
- ☐ Minor Modification
- ☐ Transfer
- ☐ Endorsement

Type of Waste:

- ☐ Hazardous Waste
- ☒ Nonhazardous Waste

Type of Facility:

- ☒ Commercial
- ☐ Noncommercial

Source of waste for noncommercial:

- ☐ Onsite
- ☐ Captured facility
- ☐ Offsite from facilities owned by owner/operator

B. Facility Name: North Texas Industrial Facility

Street Address: 2559 FM 66
City, State, Zip: Itasca, Texas 76055
Mailing Address: 2559 FM 66
Mailing City, State, Zip: Itasca, Texas 76055
County: Hill
TCEQ Solid Waste Registration (SWR) Number: 98010
EPA ID Number: TXR000085639

Give a description of the location of the facility site with respect to known or easily identifiable landmarks. Detail the access routes from the nearest U.S. or State Highway to the facility: This facility is located on FM 66, approximately 0.5 miles East of its junction with Texas Interstate 35W.

Is the facility located within the Coastal Management Program boundary? Refer to Texas Coastal Management Boundary Map[1] for boundary. For questions regarding the Coastal Management Program, please call (800) 998-4456 (within Texas) or (512) 475-0773. [30 TAC §281.41]

☐ Yes ☒ No

Provide the location of the injection well relative to established surveys:

The well will be located approximately 8,744 feet from the north line and approximately 4,714 feet from the east line of the O Wheeler Survey, A-940.

Enter the geographical coordinates of the injection well in decimal degrees to 6 decimal places:

Surface Latitude: 32.193586
Surface Longitude: -97.107806

Provide the depths of the Injection Zone and Injection Interval:

Injection Zone: Ellenburger Formation(s) at depths of 8,520 to 12,320 feet below ground level.

Injection Interval: Ellenburger Formation(s) at depths of 8,520 to 12,320 feet below ground level

C. Operator/Applicant (Individual, Corporation, or other Legal Entity Name)

Name: Republic Industrial and Energy Solutions, LLC (RIES)
Street Address: 18500 N. Allied Way
City, State, Zip: Phoenix, AZ 85054-6164
Telephone Number: (254) 687-2511

If the application is submitted on behalf of a corporation or other business organization with filing requirements, please identify the Charter Filing Number as recorded with the Office of the Secretary of State for Texas.

Charter Filing Number: 802659631

Is the applicant required to designate a registered agent with the Secretary of State of Texas?

☒ Yes ☐ No

If the application is submitted by a business organization that is required to designate and maintain a registered agent, the applicant must provide the name and address of the registered agent.

Agent: CT Corporation System
Address: 1999 Bryan Street St. 900
City, State, and Zip: Dallas, TX 75201
Phone: 214-979-1172

D. Facility Owner(s) (Individual, Corporation, or other Legal Entity Name):

The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste. The facility owner must be consistent with the owner on the deed filing bearing the stamp of the county property records or other generally accepted identifying reference of the current

ownership record provided in Section I.P.5, Attachment C of the application. If the facility owner is the same as the operator, state "same as operator". If the facility land, structures, appurtenances, and improvements on the land are owned by more than one individual, corporation or other legal entity, provide the following information for all owners. Clearly identify the relationship(s) between the operator and all facility owner(s). [THSC §361.087(1)]

Facility/Land Owner

Name:	Itasca Landfill TX, LP
Street Address:	18500 N. Allied Way
City, State, Zip:	Phoenix, AZ 85054-6164
Telephone Number:	(254) 687-2511
Charter Filing Number:	800036031

Operator

Name:	Republic Industrial and Energy Solutions, LLC
Street Address:	18500 N. Allied Way
City, State, Zip:	Phoenix, AZ 85054-6164
Telephone Number:	(254) 687-2511
Charter Filing Number:	802659631

RIES (Operator) has entered into an operating agreement with Itasca Landfill (Facility/Land owner) to permit, construct, and operate a Commercial Class I Non-Hazardous Injection Well at the Itasca Landfill facility.

E. Indicate the ownership status of the facility.

Private:

- ☐ Corporation
- ☒ Partnership
- ☐ Proprietorship
- ☐ Nonprofit organization

The property is owned by Itasca Landfill TX, LP, a limited partnership, but the assets will be owned by Republic Industrial and Energy Solutions, LLC, a corporation as per the Operating Agreement between the two entities and is submitted as a part of this application.

Public:

- ☐ Military
- ☐ State
- ☐ Regional
- ☐ County
- ☐ Municipal
- ☐ Federal

Other (specify): _____

F. List those persons or firms authorized to act for the applicant during the processing of the permit application. Indicate the capacity in which each person may represent the applicant (engineering, geology, legal, etc.). The person listed first will be the primary recipient of correspondence regarding this application. Include complete mailing addresses, phone numbers and e-mail addresses.

ALL CAPACITIES

Gary McCuistion
Republic Services
10613 W. Sam Houston Parkway North, Suite 300
Houston, TX 77064
Office Phone: 832-399-4516
Cell Phone: 713-574-0218
Email: gmccuistion@republicservices.com

GEOLOGY, ENGINEERING, AREA OF REVIEW

Ray Steppe, PE
WSP USA
16200 Park Row, Suite 200
Houston, TX 77084
Phone: 281-589-5988
Email: ray.steppe@wsp.com

G. For new, renewal, and major amendment applications specify the individual who will be responsible for causing notice to be published in the newspaper. Include the complete mailing address, telephone number, fax number and e-mail address.

Gary McCuistion
Republic Services
10613 W. Sam Houston Parkway North, Suite 300
Houston, TX 77064
Office Phone: 832-399-4516
Cell Phone: 713-574-0218
Email: gmccuistion@republicservices.com

H. Describe the activities conducted by the applicant which require a permit.

RIES proposes to operate a nonhazardous wastewater disposal facility which accepts municipal landfill leachate and Texas Class 1 and Class 2 Industrial wastewaters. The applicant is interested in drilling a Class I nonhazardous commercial well for the disposal of such waste streams.

I. For amendment, modification, transfer or endorsement applications, briefly describe all requested changes to the permit and to the application contents and the reasons for the changes.

Not Applicable

J. Business Information

1. Give a brief description of the nature of your business.

   RIES will operate a commercial nonhazardous wastewater disposal well and commercial disposal facility at the North Texas Industrial Facility, Itasca, Texas.

2. List the principal products and/or services which are provided by your plant. Please itemize by Standard Industrial Classification (SIC) codes. Also label the products with their common names, if applicable.

   SIC 4953 Refuse Systems (other nonhazardous disposal)

   SIC 4959 All other Miscellaneous Waste Management Services

K. Applicant Compliance History

The Texas Commission on Environmental Quality (TCEQ) will utilize compliance history when making decisions regarding the issuance, renewal, amendment, modification, denial, suspension, or revocation of a permit. Violations included in a criminal conviction are considered when evaluating and classifying the site's compliance history.

For the five years preceding the filing date of this application, please submit a complete listing of all criminal convictions (i.e., State or Federal) of the owner, operator or applicant in which a violation of environmental law was an element of the crime. [30 TAC §60.2(d)(1)(E) and §60.2(d)(2)(F)] If there have been no such convictions then the application should state in a separate sentence for the owner applicant and operator the following:

"In the five years preceding the filing of this application the (applicant, operator), Republic Industrial and Energy Solutions, LLC, has not been convicted of a State or Federal crime in which a violation of environmental law was an element of the crime."

"In the five years preceding the filing of this application the (facility owner), Itasca Landfill TX, LP, has not been convicted of a State or Federal crime in which a violation of environmental law was an element of the crime."

L. TCEQ Core Data Form

The TCEQ requires that a Core Data Form[2] (TCEQ-10400) be submitted with all new and renewal applications. Submit the form as "Attachment A". For all other applications, if a Regulated Entity Number (RN) and Customer Reference Number (CN) have been issued by the TCEQ and core data information has not changed, a Core Data Form is not required. For more information regarding the Core Data Form, call (512) 239-5175 or go to the Core Data Form Instructions[3] on the TCEQ website.

The TCEQ Core Data Form is included as Attachment A.

M. Public Interest Demonstration

Section 27.051 of the Texas Water Code (TWC) stipulates certain conditions that must exist for the Commission to grant an application and issue a permit. For all

new applications, permit renewals, and permit amendments, submit as "Attachment A" information addressing the following considerations:

See Attachment B: Public Interest Demonstration

1. That the use or installation of the injection well is in the public interest. [TWC §27.051(a)(1)]
2. That no existing rights, including, but not limited to, mineral rights, will be impaired. [TWC §27.051(a)(2)]
3. That, with proper safeguards, both ground and surface fresh water can be adequately protected from pollution. [TWC §27.051(a)(3)]
4. That the applicant has made a satisfactory showing of financial responsibility if required by Section 27.073 of this code. [TWC §27.051(a)(4)]
5. That the compliance history of the applicant and related entities is acceptable. [TWC §27.051(d)(1), 30 TAC § 331.121(b)(1)]
6. That there is no practical, economic, and feasible alternative to an injection well reasonably available. Provide justification for subsurface disposal. Include results of treatability studies of alternate, practical, economic and feasible methods of waste disposal. Explain in detail why each method is considered to be less satisfactory in terms of environmental protection than the proposed subsurface disposal method. Indicate whether this waste is presently being produced and, if so, what method is used for disposal. Describe the manufacturing process(es) and product(s) which produce the waste(s). [TWC §27.051(d)(2), 30 TAC § 331.121(b)(2)]
7. (for hazardous waste injection wells only) That the applicant has provided for the proper operation of the proposed hazardous waste injection well. [TWC §27.051(a)(5)]
8. (for hazardous waste injection wells only) That the applicant for a hazardous waste injection well not located in an area of industrial land use has made a reasonable effort to ensure that the burden, if any, imposed by the proposed hazardous waste injection well on local law enforcement, emergency medical or fire-fighting personnel, or public roadways, will be reasonably minimized or mitigated. [TWC §27.051(a)(6)]
9. (for hazardous waste injection wells only) That the applicant owns or has made a good faith claim to own, or has the consent of the owner to utilize, or has an option to acquire, or has the authority to acquire through eminent domain, the property or portions of the property where the hazardous waste injection well will be constructed. [TWC §27.051(a)(7)]
10. (for hazardous waste injection wells only) That the applicant will maintain sufficient public liability insurance for bodily injury and property damage to third parties that is caused by sudden and non-sudden accidents or will otherwise demonstrate financial responsibility in a manner adopted by the

Commission in lieu of public liability insurance. [TWC §27.051(d)(3), 30 TAC § 331.121(b)(3)]

11. (for hazardous waste injection wells only) For on-site generated waste, provide certification by the owner/operator that (1) the generator of the hazardous waste has a program to reduce the volume or quantity and toxicity of the waste to the degree determined by the generator to be economically practicable, and (2) injection of the waste is that practicable method of disposal currently available to the generator which minimizes the present and future threat to human health and the environment. [30 TAC §331.121(b)(4)]

N. For applications for new permits, renewals, and major amendments a copy of the administratively complete application and subsequent revisions must be made available at a public place in the county where the facility is located or proposed to be located for review and copying by the public. Identify the public place in the county (e.g., public library, county courthouse, city hall), including the address, where the application will be located. [30 TAC §39.405(g)]

Hillsboro City Library
118 South Waco Street
Hillsboro, TX 76645

O. Facility Background Information [30 TAC §305.45(a)(7)]

Indicate (by listing the permit number(s) and governing agency(ies) in the columns below) all existing, pending, interim status, or permit-by-rule State and/or Federal permits, licenses or construction approvals which pertain to pollution control or industrial solid waste management activities conducted by your plant or at your location, or existing at a proposed plant or location. Complete each blank by entering either the permit number or the date of application, and the governing agency or none.

Existing Permits

Relevant Program and/or Law	Permit Number or License	Government Agency *
Hazardous Waste Management Program under the Texas Solid Waste Disposal Act	None	
UIC Program under the Texas Injection Well Act (Class I, II, III, IV, V and VI Wells)	None	
Texas Pollutant Discharge Elimination System Program under the Clean Water Act and Waste Discharge Program under the Texas Water Code, Chapter 26	None	
Prevention of Significant Deterioration Program under the Federal Clean Air Act (FCAA)	None	
Nonattainment Program under the FCAA	None	
National Emission Standards for Hazardous Air Pollutants preconstruction approval under the FCAA	None	
Ocean dumping permits under the Marine Protection Research and Sanctuaries Act	None	

Dredge or fill permits under the Federal Clean Water Act	None	
Licenses under the Texas Radiation Control Act	None	
Subsurface Area Drip Dispersal System permits under Texas Water Code, Chapter 32	None	
Texas Solid Waste Disposal Act	None	
Texas Uranium Surface Mining and Reclamation Act	None	
Texas Surface Coal Mining and Reclamation Act	None	
Other relevant environmental permits/licenses: Industrial Solid Waste Permit (ISWR) Industrial Solid Waste (EPA ID)	 98010 TXR000085639	 TCEQ EPA

*Use the following acronyms for each agency:
TCEQ = Texas Commission on Environmental Quality
RRC = Railroad Commission of Texas
DSHS = Department of State Health Services
TDA = Texas Department of Agriculture
EPA = U.S. Environmental Protection Agency
CORPS = U.S. Army Corps of Engineers

P. Location

1. Is the facility located on Indian lands?

☐Yes ☒ No

If yes, do not complete this application. Contact EPA Region 6 for application and permitting requirements for injection wells located on Indian lands. [40 CFR §147.2205(a)]

2. Is the facility located in an area in which the governing body of the county or municipality has prohibited the processing or disposal of municipal hazardous waste or industrial solid waste?

☐Yes ☒ No

If yes, do not complete this application. TCEQ may not grant an application for an injection well permit in this area. [THSC §363.112(d)]

3. If the facility is a new commercial hazardous waste management facility, or the subsequent areal expansion of such a facility, is the boundary of the well or pre-injection units to be located within ½ of a mile of an established residence, church, school, day care center, surface water body used for public drinking water supply, or dedicated park?

☐Yes ☒ No

If yes, do not complete this application. TCEQ may not issue a permit for a facility in this location. [30 TAC §335.205(a)(3)]

4. Is the location or proposed location of the injection well in the territory of a groundwater conservation district? To determine if the injection well is or will

be located in the territory of a groundwater conservation district refer to the Texas Groundwater Conservation District map[4] on the TWDB website.

☒ Yes ☐ No

If yes, provide the contact name and mailing address for the groundwater conservation district. To obtain a point of contact and mailing address refer to the Groundwater Conservation Districts Contact List[5] on the TCEQ website. [TWC §27.017(b)]

Ms. Kathy Turner Jones
Prairielands Groundwater Conservation District
208 Kimberly Dr.
Cleburne, Texas 76031

Shauna Fitzsimmons Sledge
SledgeLaw Group PLLC
Attorneys at Law – Governmental Relations
P.O. Box 66367, Texas 78766

5. Legal Description of Facility Land

Submit, as "Attachment C", a legal description of the tract or tracts of land upon which the facility is or will be located and the deed filing bearing the stamp of the county property records or other generally accepted identifying reference of the current ownership record. If ownership of the property is transferring and new ownership documents are not final, provide the date upon which the documents will be submitted. The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste including pre-injection units used for storage and processing waste to be injected into the injection well. The legal description should include the metes and bounds description or for platted urban sites the final plat with appropriate "lot" description(s). [THSC §361.087(2)]

The Metes and Bounds Description of the NTI Facility is provided as Attachment C-1. The facility lies within the boundary of the Itasca Landfill facility. RIES will lease the property from Itasca Landfill, and the legal description of the Itasca Landfill is provided as Attachment C-2.

6. Submit, as "Attachment D", a drawn-to-scale topographic map of the facility and the tract or tracts of land upon which the facility is or will be located as described in Attachment C and area extending at least one mile beyond the tract boundaries. The map must be prepared by a licensed professional engineer or a registered surveyor. The scale should be adequate to depict the following features: [30 TAC §305.45(a)(6)(A), (C) & (E)]

The overall facility layout is presented in Attachment D-1. The topographic map of the facility and the location water wells can be found in Attachment D-2. The information pertinent to each water

well can be found in Table VIII-2. The locations of oil and gas wells in the vicinity of the facility and within the area of review are illustrated on Attachment D-3. The information pertinent to each artificial penetration well can be found in Table VIII-1. The area within the NTI facility boundary is 3.428 acres. Attachments D-1 through D-3 have the area size of the facility in acres on the map.

1) the boundary of the tract or tracts of land upon which the facility is or will be located as described in Attachment C; areal size of the tract or tracts of land in acres should be given;

2) if different, the boundary of the facility, and the location of all injection wells; each depicted area should be labeled to identify the well(s) and the well status (active, inactive, or proposed); areal size of the facility in acres should be given;

3) if applicable, the boundaries of captured facilities that generate waste to be disposed in the injection wells, each depicted area should be labeled to identify the names of the captured facilities;

4) the overall facility, each of its surface intake and discharge structures, each of its waste treatment, storage or disposal facilities, including proposed or existing pre-injection units for processing or storage of waste to be disposed in the injection wells; and

5) all wells (water, oil and gas, disposal, etc.), springs, other surface water bodies, and drinking water wells listed in public records or otherwise known to the applicant within one mile of the facility property boundary, and the purpose for which each water well is used (e.g., domestic, livestock, agricultural, industrial, etc.).

Q. Plain-Language Summary

The TCEQ implemented new rule requirements in 30 TAC Chapter 39 that impact all permit applications subject to the Chapter 39 public notice requirements that are declared administratively complete after May 1, 2022. One of the new rules, 30 TAC §39.405(k), requires the applicant to provide a plain-language summary in English, and in an alternative language if required in accordance with 30 TAC §39.426. The plain-language summaries for all applications will be posted on the TCEQ website.

For new, renewal and major amendment permit applications submit, as "Attachment E", a Plain-Language Summary of the application that is no more than two pages long. The summary should be entitled "Plain-Language Summary" and should be prepared in simple, concise, easy-to-understand terminology. The summary must include the following information. [30 TAC §39.405(k)]

See Attachment E: Plain Language Summary

1. the applicant/operator name;

2. the type of application;

3. the type of waste;
4. the type of facility;
5. the facility name and location;
6. the function of the proposed plant or facility;
7. the expected output of the proposed plant or facility;
8. the expected pollutants that may be emitted or discharged by the proposed plant or facility which require an injection well permit; and
9. how the applicant will control those pollutants, so that the proposed plant will not have an adverse impact on human health or the environment.

If the applicant is required to provide notice in an alternative language in accordance with 30 TAC §39.426, provide a copy of the plain-language summary in English and in the alternative language.

In addition, provide a copy of the plain-language summaries in pdf clearly labeled on a flash drive.

R. Public Involvement Plan

TCEQ's Public Participation Plan provides guidance for using preliminary screening and public involvement plans to ensure meaningful public outreach. Applicants who are applying for a new injection well permit are required to complete a Public Involvement Plan. A Public Involvement Plan is intended to provide an applicant and the agency with information to determine if additional public outreach is necessary or beneficial. Applicants may complete a Public Involvement Plan, even if not required, to learn about the communities in which their facilities are located or where their activities may have an impact.

Submit a Public Involvement Plan, as "Attachment F", using the Public Involvement Plan Form[6] (TCEQ-20960) and Instructions for Completing a Public Involvement Plan Form for Permit and Registration Applications[7] (TCEQ-20960).

See Attachment F: Public Involvement Plan

For more information regarding Title VI compliance at TCEQ[8] or the Public Participation Plan[9] go on the TCEQ website.

(b) OPERATOR/OWNER SIGNATURE PAGE

I (Signatory Name) Vincent Scheerer (Title) Vice President (Company) Republic Industrial and Energy Solutions, LLC certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature _____ Date December 4, 2023

See 30 TAC §305.44 for signatory authority.

Applications must be signed by the facility owner(s) and operator of the facility. The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste. Duplicate this page for additional signatories.

To Be Completed by the Applicant if the Applicant Is a Corporation and the Responsible Corporate Officer Is Assigning or Delegating Signature Authority to a Manager in Accordance with 30 TAC §305.44(a)(1)

I (Signatory Name) _____ (Title) _____ (Company) _____ hereby designate (Agent Name and/or Title) _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Commission, and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

Signature _____ Date _____

(Note: Application Must Bear Signature and Seal of Notary Public)

SUBSCRIBED AND SWORN to before me by the said Vince Scheerer

on this 4th day of December, 2023

My commission expires on the 10 day of Nov, 2025

ALYSON TOUPS
Notary ID #11030467
My Commission Expires
November 10, 2025

Notary Public

(c) LANDOWNER SIGNATURE PAGE

I (Signatory Name) Yasser Brenes (Title) Vice President (Company) Itasca Landfill TX, LP certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature _____ Date 12/12/23

See 30 TAC §305.44 for signatory authority.

Applications must be signed by the facility owner(s) and operator of the facility. The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste. Duplicate this page for additional signatories.

To Be Completed by the Applicant if the Applicant Is a Corporation and the Responsible Corporate Officer Is Assigning or Delegating Signature Authority to a Manager in Accordance with 30 TAC §305.44(a)(1)

I (Signatory Name) _____ (Title) _____ (Company) _____ hereby designate (Agent Name and/or Title) _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Commission, and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

Signature _____ Date _____

(Note: Application Must Bear Signature and Seal of Notary Public)

SUBSCRIBED AND SWORN to before me by the said Yasser Brenes

on this 12th day of December, _____

My commission expires on the 1st day of November, 2024

ANA L. GALLARDO
MY COMMISSION EXPIRES
NOVEMBER 1, 2024
NOTARY ID: 125104064

Ana L. Gallardo
Notary Public

(b) OPERATOR SIGNATURE PAGE

I (Signatory Name) Vincent Scheerer (Title) Vice President (Company) Republic Industrial and Energy Solutions, LLC certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature _____ Date 5-16-2024

See 30 TAC §305.44 for signatory authority.

Applications must be signed by the facility owner(s) and operator of the facility. The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste. Duplicate this page for additional signatories.

To Be Completed by the Applicant if the Applicant Is a Corporation and the Responsible Corporate Officer Is Assigning or Delegating Signature Authority to a Manager in Accordance with 30 TAC §305.44(a)(1)

I (Signatory Name) _____ (Title) _____ (Company) _____ hereby designate (Agent Name and/or Title) _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Commission, and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

Signature _____ Date _____

(Note: Application Must Bear Signature and Seal of Notary Public)

SUBSCRIBED AND SWORN to before me by the said Vince Scheerer

on this 16th day of May, 2024

My commission expires on the 10th day of November, 2025

NOTARY PUBLIC STATE OF TEXAS
ALYSON TOUPS
Notary ID #11030467
My Commission Expires
November 10, 2025

_____
Notary Public

(c) FACILITY/LANDOWNER SIGNATURE PAGE

I (Signatory Name) Yasser Brenes (Title) Vice President (Company) Itasca Landfill TX, PP certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature _____ Date 5/16/24

See 30 TAC §305.44 for signatory authority.

Applications must be signed by the facility owner(s) and operator of the facility. The facility includes all contiguous land, and structures, other appurtenances, and improvements on the land, used for storing, processing, or disposing of waste. Duplicate this page for additional signatories.

To Be Completed by the Applicant if the Applicant Is a Corporation and the Responsible Corporate Officer Is Assigning or Delegating Signature Authority to a Manager in Accordance with 30 TAC §305.44(a)(1)

I (Signatory Name) _____ (Title) _____ (Company) _____ hereby designate (Agent Name and/or Title) _____ as my agent and hereby authorize said agent to sign any application, submit additional information as may be requested by the Commission, and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my agent in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

Signature _____ Date _____

(Note: Application Must Bear Signature and Seal of Notary Public)

SUBSCRIBED AND SWORN to before me by the said Yasser Brenes

on this 16th day of May, 2024

My commission expires on the 1st day of November, 2024

ANA L. GALLARDO
MY COMMISSION EXPIRES
NOVEMBER 1, 2024
NOTARY ID: 125104064

Ana L. Gallardo
Notary Public

ATTACHMENTS

ATTACHMENT A

TCEQ Use Only

TCEQ Core Data Form

For detailed instructions on completing this form, please read the Core Data Form Instructions or call 512-239-5175.

SECTION I: General Information

1. Reason for Submission *(If other is checked please describe in space provided.)*		
☒ New Permit, Registration or Authorization (*Core Data Form should be submitted with the program application.)*		
☐ Renewal *(Core Data Form should be submitted with the renewal form)*		☐ Other
2. Customer Reference Number *(if issued)*	Follow this link to search for CN or RN numbers in Central Registry**	**3. Regulated Entity Reference Number** *(if issued)*
CN 605333087		RN 111269171

SECTION II: Customer Information

4. General Customer Information	**5. Effective Date for Customer Information Updates** (mm/dd/yyyy)	
☐ New Customer ☒ Update to Customer Information ☐ Change in Regulated Entity Ownership ☐ Change in Legal Name (Verifiable with the Texas Secretary of State or Texas Comptroller of Public Accounts)		
The Customer Name submitted here may be updated automatically based on what is current and active with the Texas Secretary of State *(SOS) or Texas Comptroller of Public Accounts (CPA).*		
6. Customer Legal Name *(If an individual, print last name first: eg: Doe, John)*	*If new Customer, enter previous Customer below:*	
Republic Industrial and Energy Solutions, LLC		

7. TX SOS/CPA Filing Number	8. TX State Tax ID (11 digits)	9. Federal Tax ID (9 digits)	10. DUNS Number *(if applicable)*
802659631	18153682143	81-5368214	080614152

11. Type of Customer:	☒ Corporation	☐ Individual	Partnership: ☐ General ☐ Limited
Government: ☐ City ☐ County ☐ Federal ☐ Local ☐ State ☐ Other		☐ Sole Proprietorship	☐ Other:

12. Number of Employees	13. Independently Owned and Operated?
☐ 0-20 ☐ 21-100 ☐ 101-250 ☐ 251-500 ☒ 501 and higher	☐ Yes ☒ No

14. Customer Role (Proposed or Actual) – *as it relates to the Regulated Entity listed on this form. Please check one of the following*

☐ Owner ☒ Operator ☐ Owner & Operator ☐ Other:
☐ Occupational Licensee ☐ Responsible Party ☐ VCP/BSA Applicant

15. Mailing Address:	18500 N. Allied Way						
	City	Phoenix	State	AZ	ZIP	85054	ZIP + 4	6164

16. Country Mailing Information *(if outside USA)*	17. E-Mail Address *(if applicable)*

18. Telephone Number	19. Extension or Code	20. Fax Number *(if applicable)*

(480) 627-2700		( ) -

SECTION III: Regulated Entity Information

21. General Regulated Entity Information *(If 'New Regulated Entity" is selected, a new permit application is also required.)*

☒ New Regulated Entity ☐ Update to Regulated Entity Name ☐ Update to Regulated Entity Information

***The Regulated Entity Name submitted may be** updated, in order to meet TCEQ Core **Data Standards (removal of organizational endings such** as Inc, LP, or LLC).*

22. Regulated Entity Name *(Enter name of the site where the regulated action is taking place.)*

North Texas Industrial Facility

23. Street Address of **the Regulated Entity:** *(No PO Boxes)*	2559 FM 66							
	City	Itasca	State	TX	ZIP	76055	ZIP + 4	
24. County	Hill							

If no Street Address is provided, fields 25-28 are required.

25. Description to Physical Location:	This facility is located on FM 66, approximately 0.5 miles East of its junction with Texas Interstate 35W, in Hill County, Texas.

26. Nearest City	State	Nearest ZIP Code
Itasca	TX	76055

***Latitude/Longitude** are required and may be added/updated to meet TCEQ Core Data Standards. (Geocoding of the Physical Address may be used to supply coordinates where none have been provided or to gain accuracy).*

27. **Latitude (N)** In Decimal:	32.193586		28. Longitude (W) In Decimal:	97.107806	
Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
32	11	33.48	97	6	26.59

29. Primary SIC Code (4 digits)	30. Secondary SIC Code (4 digits)	31. Primary NAICS Code (5 or 6 digits)	32. Secondary NAICS Code (5 or 6 digits)
4953	4212	562212	811310

33. What is the Primary Business of this entity? *(Do not repeat the SIC or NAICS description.)*

Und. Inj. Disposal of Non-Haz Waste

34. Mailing Address:	2559 FM 66							
	City	Itasca	State	TX	ZIP	70655	ZIP + 4	
35. E-Mail Address:	**gmccuistion@republicservices.com**							

36. Telephone Number	37. Extension or Code	38. Fax Number *(if applicable)*
(832) 399-4516 or (713) 574-0218		( ) -

39. TCEQ Programs and ID Numbers Check all Programs and write in the permits/registration numbers that will be affected by the updates submitted on this form. See the Core Data Form instructions for additional guidance.

☐ Dam Safety	☐ Districts	☐ Edwards Aquifer	☐ Emissions Inventory Air	☐ Industrial Hazardous Waste
☐ Municipal Solid Waste	☐ New Source Review Air	☐ OSSF	☐ Petroleum Storage Tank	☐ PWS
☐ Sludge	☐ Storm Water	☐ Title V Air	☐ Tires	☐ Used Oil
☐ Voluntary Cleanup	☐ Wastewater	☐ Wastewater Agriculture	☐ Water Rights	☒ Other:
				Industrial Waste Permit (ISWR 98010)

SECTION IV: Preparer Information

40. Name:	Morgan Canezaro	**41. Title:**	Lead Geologist

42. Telephone Number	**43. Ext./Code**	**44. Fax Number**	**45. E-Mail Address**
(225) 508-3861		( ) -	Morgan.Canezaro@wsp.com

SECTION V: Authorized Signature

46. By my signature below, I certify, to the best of my knowledge, that the information provided in this form is true and complete, and that I have signature authority to submit this form on behalf of the entity specified in Section II, Field 6 and/or as required for the updates to the ID numbers identified in field 39.

Company:	Republic Industrial and Energy Solutions, LLC	**Job Title:**	Vice President
Name *(In Print):*	Vincent Scheerer	**Phone:**	(254) 687 - 2511
Signature:		**Date:**	05/28/2024

ATTACHMENT B

ATTACHMENT B

PUBLIC INTEREST DEMONSTRATION

M. Public Interest Demonstration

Section 27.051 of the Texas Water Code (TWC) stipulates certain conditions that must exist for the Commission to grant an application and issue a permit. For all new applications, permit renewals, and permit amendments, submit as "Attachment A" information addressing the following considerations:

1. That the use or installation of the injection well is in the public interest. [TWC §27.051(a)(1)]

   The installation of the proposed injection serves the public interest because the injection well will be designed to provide a safe, proven, accepted technology for waste disposal that is superior to other technologies available and investigated for management of hazardous waste. Proper management and disposal of nonhazardous industrial wastes are essential to business owners and to the public interest in Texas.

2. That no existing rights, including, but not limited to, mineral rights, will be impaired. [TWC §27.051(a)(2)]

   No existing rights are impaired through the installation and use of the injection well, since the geologic formations in use have little economic value to mineral owners. The locations of oil and gas wells have been provided. In addition, the TCEQ has been provided a listing of affected adjacent surface landowners and mineral owners surrounding the North Texas Industrial Facility. The waste plumes generated are contained in the defined injection interval for long-term confinement. No mineral rights will be impaired, since injection is confined to the permit-authorized Ellenburger sands, which are barren of oil and gas in the 2.5-mile area of review and cone of influence investigated. This conclusion is based on a review of electric logs of multiple wells drilled for oil and gas where no hydrocarbons were encountered, and the wells were plugged as dry holes.

3. That, with proper safeguards, both ground and surface fresh water can be adequately protected from pollution. [TWC §27.051(a)(3)]

   The Class I disposal well at this facility will be constructed and operated in accordance with all applicable rules and regulations of the State of Texas.

The proposed injection well will be constructed to ensure that ground water and surface waters are adequately protected from the injected wastes. Class I wells offer superior protection with a known and proven technology employed from years of use in the oil and gas industry. Proper safeguards that will be applied: 1) favorable injection interval geology, 2) stringent well installation/construction standards, 3) regulatory oversight and reporting, 4) annual mechanical integrity testing of well completion, and 5) operational permit limitations-pressure, volume, fluid density, and pH restrictions.

Several groundwater protection safeguards will be implemented for the proposed well construction consisting of: geologic formations, drilling mud, cement, casing strings, annulus fluid monitoring, and injection tubing, all of which offer exceptional confinement and isolation of the injected waste from the shallow base of the lowermost underground source of drinking water (USDW-- defined as ground water with a concentration of total dissolved solids less than 10,000 mg/L). This vertical section contains multiple casing strings and continuous cement sheaths, all of which provide the isolation and confinement that insures protection of the shallow ground water zones.

4. That the applicant has made a satisfactory showing of financial responsibility if required by Section 27.073 of this code. [TWC §27.051(a)(4)]

   Republic Industrial and Energy Solutions, LLC has provided documentation of financial responsibility in Attachment F found in Section IV.

5. That the compliance history of the applicant and related entities is acceptable. [TWC §27.051(d)(1), 30 TAC §331.121(b)(1)]]

   In the five years preceding the filing of this application, Republic Industrial and Energy Solutions, LLC has not been convicted of a State or Federal crime in which a violation of environmental law was an element of the crime.

6. That there is no practical, economic, and feasible alternative to an injection well reasonably available. Provide justification for subsurface disposal. Include results of treatability studies of alternate, practical, economic and feasible methods of waste disposal. Explain in detail why each method is considered to be less satisfactory in terms of environmental protection than the proposed subsurface disposal method. Indicate whether this waste is presently being produced and if so, what method is used for disposal. Describe the manufacturing process(es) and product(s) which produce the waste(s). [TWC §27.051(d)(2), 30 TAC §331.121(b)(2)]

   No viable, practical, economic, and feasible waste disposal alternative to injection well technology is reasonably available today. North Texas

Industrial Facility will be a commercial injection facility offering disposal options for various industries. With large volumes of aqueous waste generated from off-site generators, it is inevitable that large quantities of liquid waste require disposal. The use of injection wells provides a competitive business and environmental advantage by managing these large volumes of aqueous wastes via an injection well in a safe, protective program, authorized by TCEQ and EPA.

Justification for Injection Well Disposal:

Underground injection has been recognized by the EPA as the preferred method for waste disposal (over landfills or other near-surface disposal options) since wastes are safely injected into geologically isolated formations far below any underground sources of drinking water. The role of chemical interaction of the underground formations with the injected waste stream is critical in assessing the degradation and neutralization of wastes in the subsurface due to temperature, pressure, salinity, buffering of pH of waste constituents. Organic constituents and pH are neutralized by interaction with the complex silicate clays present in the sand matrix.

The advantage of using deep-wells for waste disposal is that no releases to surface water, no air emissions, and no CO_2 or carbon releases occur, and that ground water and human health are protected.

Alternative Technologies:

Landfill— Republic Industrial and Energy Solutions, LLC has been using landfills. However, landfills are designed for solid waste. Treatment (Stabilization/Solidification) of aqueous waste required before landfill disposal has become cost prohibitive.

Incinerator—Large aqueous hazardous waste volumes are prohibitive from 'burning' due to large energy impetus required, the
the human health exposure and capital cost for such. In addition, the developed process gases, waste stream incinerated metals and other particulates would likely cause health issues when air-wind dispersion was not at its greatest. These residual concentrated particulates and incinerator ash must be landfilled, which would likely create an additional exposure to the environment in such a populated area. More importantly, the disadvantage of frequent use of incineration would result in high loads and release levels of available Carbon, in the form of Carbon dioxide, as well as associated Sulfur dioxide and Nitrogen oxide (NOx) compounds, which would increase in the near environment.

<u>Surface Bio-Ponds</u>—Various wastewater streams have been successfully treated via biological activity in surface ponds, however they do not consist of low-pH or high-pH aqueous wastes with significant metal and organic contents.

This commercial facility receives many different types of nonhazardous industrial wastes from numerous generators. It is therefore not possible to provide a description of the physical and chemical characteristics for each nonhazardous industrial waste that is received here, nor is it possible to describe the manufacturing and/or industrial processes from which each waste was generated.

Any waste that is received, however, must meet the following requirements for acceptance:

1. **Each waste must be classified as nonhazardous under 40 CFR 261 (EPA regulations for identifying hazardous wastes) and 33 TAC 335, Subchapter R (TCEQ Waste Classification Guidelines).**
2. **It is the waste generator's responsibility to determine the classification of his waste and to provide evidence of this determination to the commercial facility.**
3. **Onsite waste acceptance and verification procedures shall confirm the waste determination as nonhazardous prior to offloading the waste shipment, and confirm the compatibility of the waste shipment with the waste storage, processing, treatment, and disposal systems utilized at this facility.**

7. (for hazardous waste injection wells only) That the applicant has provided for the proper operation of the proposed hazardous waste injection well. [TWC §27.051(a)(5)]

   Not applicable.

8. (for hazardous waste injection wells only) That the applicant for a hazardous waste injection well not located in an area of industrial land use has made a reasonable effort to ensure that the burden, if any, imposed by the proposed hazardous waste injection well on local law enforcement, emergency medical or fire-fighting personnel, or public roadways, will be reasonably minimized or mitigated. [TWC §27.051(a)(6)]

   Not applicable.

9. (for hazardous waste injection wells only) That the applicant owns or has made a good faith claim to, or has the consent of the owner to utilize, or has an option to

acquire, or has the authority to acquire through eminent domain, the property or portions of the property where the hazardous waste injection well will be constructed. [TWC §27.051(a)(7)]

Not applicable.

10. (for hazardous waste injection wells only) That the applicant will maintain sufficient public liability insurance for bodily injury and property damage to third parties that is caused by sudden and non-sudden accidents or will otherwise demonstrate financial responsibility in a manner adopted by the Commission in lieu of public liability insurance. [TWC §27.051(d)(3). §331.121(b)(3)]

    Not applicable.

11. (for a hazardous waste injection wells only) For on-site generated waste, provide certification by the owner/operator that (1) the generator of the hazardous waste has a program to reduce the volume or quantity and toxicity of the waste to the degree determined by the generator to be economically and practicable, and (2) injection of the waste is that practicable method of disposal currently available to the generator which minimizes the present and future threat to human health and the environment. [30 TAC §331.121(b)(4) and 40 CFR §146.70(d)]

    Not applicable.

ATTACHMENT C

ATTACHMENT C-1

NTI METES AND BOUNDS

ATTACHMENT C-1

METES & BOUNDS DESCRIPTION

BEING a 3.428–acre tract situated in the ORLANDO WHEELER SURVEY, ABSTRACT No. 940, Hunt County, Texas, and being a portion of that certain 360.451 acre tract conveyed to Itasca Landfill TX, LP as described as "Parcel 1" in Volume 1155, Page 257 in the Deed Records of Hill County, Texas, (D.R.H.C.T.) and recorded on March 14, 2002, said 3.428–acre tract being more particularly described as follows:

COMMENCING at a 7/8–inch pipe found in the northwesterly line of said 360.451–acre tract and being the southwest corner of a called 65.307–acre tract conveyed to said Itasca Landfill TX, LP and described as "Parcel 2" in said Volume 1155, Page 257 (D.R.H.C.T.), having local site coordinates of N: 191,262.85, E: 2,119,698.93, and from which a 60 penny nail found in said northwesterly line of said 360.451–acre tract bears South 60 degrees 56 minutes 55 seconds West, 1,568.90 feet (called North 60 degrees 57 minutes 23 seconds East, 1,568.49 feet);

THENCE North 61 degrees 01 minutes 08 seconds East (called North 60 degrees 59 minutes 46 seconds East) with the common line of said 360.451–acre and said 65.607–acre tracts, 1,669.39 feet to a point;

THENCE South 28 degrees 58 minutes 52 seconds East, projecting into said 360.451–acre tract, 110.34 feet to a point for the POINT OF BEGINNING of the hereinafter described tract and having local site coordinates of N: 191,975.19, E: 2,121,212.75:

THENCE (L2) North 66 degrees 43 minutes 17 seconds East, 300.00 feet to a point, from which a 1/2–inch rebar set for reference bears North 44 degrees 26 minutes 22 seconds East, 202.83 feet;

THENCE (L3) South 23 degrees 16 minutes 43 seconds East, 300.00 feet to a point;

THENCE (L4) South 11 degrees 43 minutes 12 seconds West, 114.39 feet to a point;

THENCE (L5) South 12 degrees 04 minutes 29 seconds East, 185.00 feet to a point, from which a 1/2–inch rebar set for reference bears South 74 degrees 57 minutes 00 seconds East, 546.07 feet;

THENCE (L6) South 35 degrees 39 minutes 02 seconds West, 161.98 feet to a point;

THENCE (L7) South 17 degrees 42 minutes 50 seconds West, 90.00 feet to a point;

THENCE (L8) North 72 degrees 17 minutes 10 seconds West, 114.00 feet to a point, from which a 1/2–inch rebar set for reference bears South 7 degrees 19 minutes 57 seconds West, 190.40 feet;

THENCE (L9) North 17 degrees 42 minutes 50 seconds East, 90.00 feet to a point;

THENCE (L10) North 44 degrees 20 minutes 14 seconds East, 171.41 feet to a point;

THENCE (L11) North 12 degrees 04 minutes 29 seconds West, 80.00 feet to a point;

THENCE (L12) North 69 degrees 45 minutes 38 seconds West, 203.67 feet to a point;

THENCE (L13) North 23 degrees 16 minutes 43 seconds West, 300.00 feet to the POINT OF BEGINNING, containing 3.428–acres or 149,324 square feet of land, more or less.

Line Table		
Line #	Bearing	Distance
L1	S28° 58' 52"E	110.34
L2	N66° 43' 17"E	300.00
L3	S23° 16' 43"E	300.00
L4	S11° 43' 12"W	114.39
L5	S12° 04' 29"E	185.00
L6	S35° 39' 02"W	161.98
L7	S17° 42' 50"W	90.00
L8	N72° 17' 10"W	114.00
L9	N17° 42' 50"E	90.00
L10	N44° 20' 14"E	171.41
L11	N12° 04' 29"W	80.00
L12	N69° 45' 38"W	203.67
L13	N23° 16' 43"W	300.00

SURVEY NOTES

1. THIS EXHIBIT AND DESCRIPTION WAS PREPARED BASED ON A FIELD SURVEY PERFORMED 2–22–2021.
2. THIS EXHIBIT WAS PREPARED WITHOUT THE BENEFIT OF A TITLE COMMITMENT AND NO EASEMENTS OR IMPROVEMENTS ARE SHOWN. CORNERS OF THE FACILITY BOUNDARY DESCRIBED HEREIN NOT SET AT DIRECTION OF THE CLIENT. FURTHER, THIS EXHIBIT IS INTENDED TO BE USED FOR SPECIFIC PERMITTING PURPOSES AND IS NOT INTENDED TO BE USED FOR CONVEYANCE OF LAND.
3. BASIS OF BEARINGS IS DERIVED FROM THE NORTHWESTERLY LINE OF SAID 360.451 ACRE TRACT RECORDED IN VOLUME 1155, PAGE 257 (D.R.H.C.T.), MEASURED AS SOUTH 60 DEGREES 56 MINUTES 55 SECONDS WEST (CALLED NORTH 60 DEGREES 57 MINUTES 23 SECONDS EAST IN SAID DEED.
4. COORDINATES SHOWN HEREON ARE BASED UPON A SITE–SPECIFIC PROJECTION LOCAL TO THE ITASCA LANDFILL AS HELD FIXED BY LOCAL SITE CONTROL POINTS.

SURVEYOR CERTIFICATION

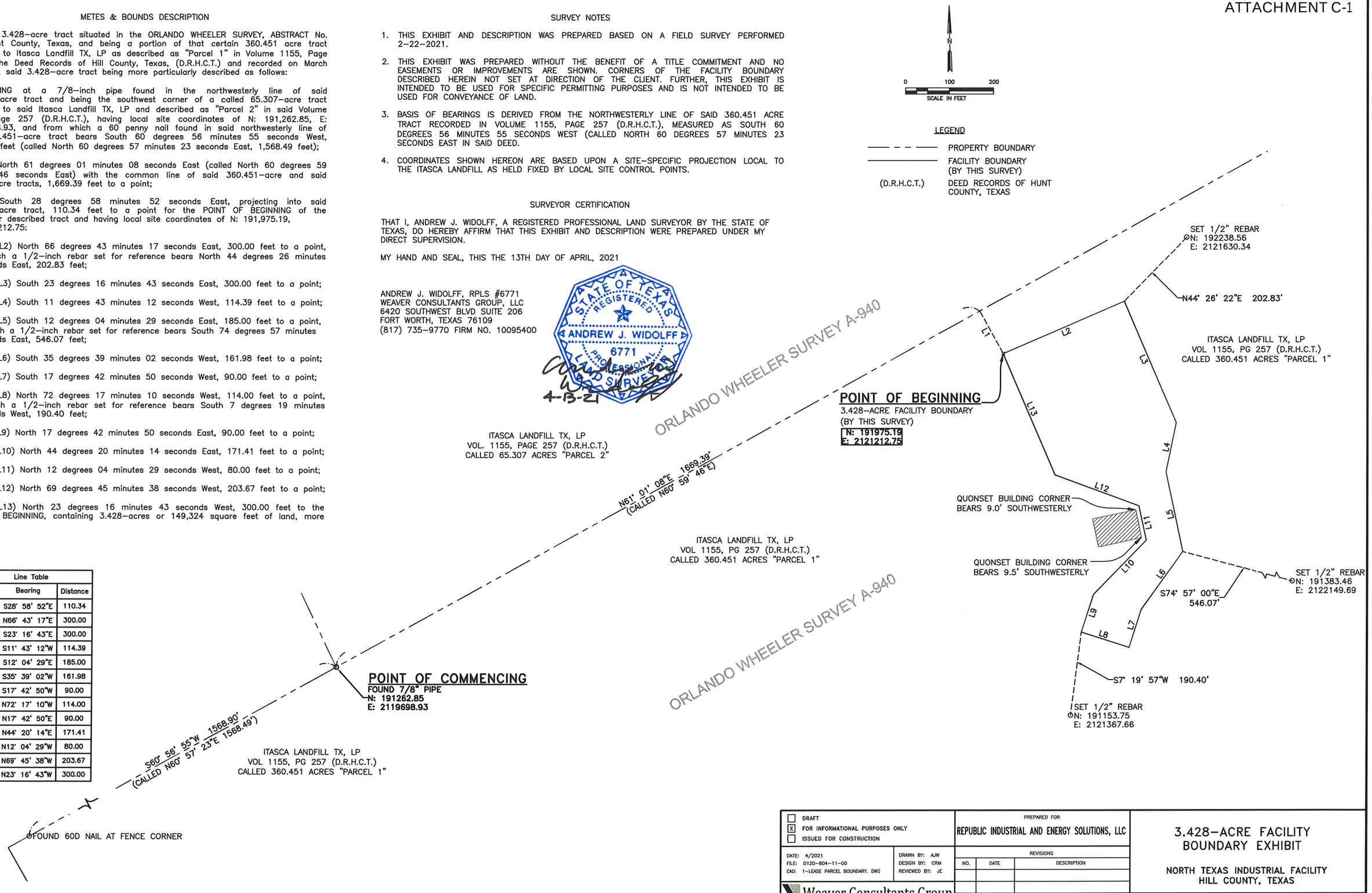
THAT I, ANDREW J. WIDOLFF, A REGISTERED PROFESSIONAL LAND SURVEYOR BY THE STATE OF TEXAS, DO HEREBY AFFIRM THAT THIS EXHIBIT AND DESCRIPTION WERE PREPARED UNDER MY DIRECT SUPERVISION.

MY HAND AND SEAL, THIS THE 13TH DAY OF APRIL, 2021

ANDREW J. WIDOLFF, RPLS #6771
WEAVER CONSULTANTS GROUP, LLC
6420 SOUTHWEST BLVD SUITE 206
FORT WORTH, TEXAS 76109
(817) 735–9770 FIRM NO. 10095400

STATE OF TEXAS REGISTERED ANDREW J. WIDOLFF 6771 PROFESSIONAL LAND SURVEYOR

4-13-21



☐ DRAFT
☒ FOR INFORMATIONAL PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 4/2021
FILE: 0120–804–11–00
CAD: 1–LEASE PARCEL BOUNDARY. DWG

DRAWN BY: AJW
DESIGN BY: CRM
REVIEWED BY: JE

Weaver Consultants Group
TBPELS ENG. FIRM NO. F–3727
TBPELS SURV. FIRM NO. 10095400

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

3.428–ACRE FACILITY BOUNDARY EXHIBIT

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING 1

COPYRIGHT © 2021 WEAVER CONSULTANTS GROUP. ALL RIGHTS RESERVED.

P:\SBI Survey\Solid Waste\0120 (Allied)\804 (Itasca-Tervita Deep Well Site)\0120-804-11-00 (Deep Well Lease Boundary)\2.0 Drawings\2.1 CAD\1-LEASE PARCEL BOUNDARY.dwg, awidolff, 1:2

ATTACHMENT C-2

SITE LEGAL DESCRIPTION

002124

SPECIAL WARRANTY DEED

THE STATE OF TEXAS)
) KNOW ALL BY THESE PRESENTS:
COUNTY OF HILL)

THAT THE UNDERSIGNED, **BFI Waste Systems of North America, Inc.**, a Delaware corporation, as successor by merger to Browning-Ferris, Inc., hereinafter referred to as "GRANTOR", whether one or more, for and in consideration of the sum of TEN DOLLARS ($10.00) cash, and other good and valuable consideration in hand paid by the Grantee, herein named, the receipt and sufficiency of which is hereby fully acknowledged and confessed, has GRANTED, SOLD and CONVEYED, and by these presents does hereby GRANT, SELL and CONVEY unto **Itasca Landfill TX, LP**, a Texas Limited Partnership, herein referred to as "GRANTEE", whether one or more, the real property described as follows:

See Exhibit "A" attached hereto and made a part hereof

This conveyance, however, is made and accepted subject to any and all validly existing encumbrances, conditions and restrictions, relating to the hereinabove described property as now reflected by the records of the County Clerk of Hill County, Texas.

TO HAVE AND TO HOLD the above described premises, together with all and singular the rights and appurtenances thereto in anywise belonging unto the said GRANTEE, GRANTEE'S heirs, executors, administrators, successors and/or assigns forever, and GRANTOR does hereby bind GRANTOR'S heirs, executors, administrators, successors and/or assigns, to WARRANT AND FOREVER DEFEND all and singular the said premises unto the said GRANTEE, GRANTEE'S heirs, executors, administrators, successors and/or assigns, against every person whomsoever lawfully claiming or to claim the same or any part thereof, except as to the reservations from and exceptions to conveyance and warranty, when the claim is by, through or under Grantor, but not otherwise.

Current ad valorem taxes on said property having been prorated, the payment thereof is assumed by GRANTEE.

EXECUTED this 31st day of December, 2001.

BFI Waste Systems of North America, Inc.

BY: _____
Jo Lynn White, Secretary

THE STATE OF ARIZONA)
)
COUNTY OF MARICOPA)

This instrument was acknowledged before me on this the 31st day of December, 2001 by Jo Lynn White, as Secretary, of BFI Waste Systems of North America, Inc.

"OFFICIAL SEAL"
Catherine Childress
Notary Public-Arizona
Maricopa County
My Commission Expires 6/29/2004

_____
NOTARY PUBLIC IN AND FOR THE STATE OF ARIZONA

MY COMMISSION EXPIRES:

_____

AFTER RECORDING RETURN TO:

Eileen B. Schuler
BFI Waste Systems of North America, Inc.
757 N. Eldridge, Suite 448
Houston, TX 77079

Parcel 1:

PROPERTY DESCRIPTION

360.451 Acres of land situated in the Orlander Wheeler Survey, Abstract No. 940, Hill County, Texas; said 360.451 acres of land being a portion of that called 360.973 acre tract of land conveyed to Browning-Ferris, Inc. as recorded in Volume 753, Page 89, Deed Records of Hill County, Texas; said 360.451 acres of land being more particularly described by metes and bound as follows:

Beginning at a 1/2 inch iron rod found in the northwesterly Row line of Farm to Market Highway No. 66 at the most southerly southwest corner of said Browning-Ferris, Inc. tract; said iron rod also being the southeast corner of a tract of land conveyed to Clarence E. Pressley and wife Susie Pressley as recorded in Volume 840, Page 543, Deed Records of Hill County, Texas, said iron rod being futher described having Texas State Plane Coordinate System, North Central Zone, NAD, 1927 coordinates of X=2,120,788.81 and Y=187,117.16. The coordinates are based upon Triangulation Station "FILES", Itasca, Hill County, Texas. The combined scale factor used to determine the coordinates is 0.999949438. The bearings are State Plane bearings.

THENCE N 23° 13' 22" W, 304.61 feet (deed N 24° 00' W, 304.67) feet along the common line of said Browning-Ferris, Inc. and said Pressley tract to a 1/2 inch iron rod found ;

THENCE N 86° 49' 31" W, 418.39 feet (deed N 88° 00' W, 419.05 feet) continuing along said common line to a 1/2 inch iron rod found near a fence corner;

THENCE S 59° 32' 42" W, 201.89 feet (deed S 58° 35' W, 202.50 feet) continuing along said common line to a 1/2 inch iron rod found near a fence corner, said iron rod being the northwest corner of said Pressley tract;

THENCE N 51° 04' 44" W, 20.29 feet (deed N 51° 38' W, 20.00 feet along a fence line and continuing along the west line of said Browning-Ferris, Inc. tract to a 1/2 inch iron rod found at an angle point in said fence line;

THENCE N 29° 31' 26" W, (deed N 30° 33' W) at 188.2 feet pass a point which is 6.6 feet easterly from a fence corner post which said fence runs southerly and westerly and continuing along the west line of said Browning-Ferris, Inc. tract in all 3,612.68 feet (deed 3613.50 feet) to the northwest corner of said Browning-Ferris, Inc. tract in a creek;

THENCE N 60° 57' 23" E, (deed N 59° 57' W) at 54.00 feet pass a 1/2 inch iron rod found on the east bank of said creek near a fence corner and continuing along the northerly line of said Browning-Ferris, Inc. tract and near a fence line 1622.49 feet to a 3/4 inch iron pipe found at a fence corner, said pipe being the southwest corner of a tract of land conveyed to Browning-Ferris, Inc. as recorded in Volume 829, Page 373, Deed Records of Hill County, Texas;

THENCE N 60° 59' 46" E, (deed N 59° 57' W) 2,439.63 feet along the common line of the two Browning-Ferris, Inc. tracts and generally along a fence line to a 1/2 inch iron rod set with plastic cap stamped "Landes & Assoc." at the northwest corner of a tract of land conveyed to The Veterans Land Board of the State of Texas as recorded in Volume 558, Page 571, Deed Records Hill County Texas;

Parcel 1 Continued:

THENCE S 30° 37' 21" E, 585.28 feet along the westerly line of said Land Board tract to an angle point in a gravel county road and in the easterly line of said Browning-Ferris, Inc. tract from which a 1/2 inch iron rod set marked as before bears S 05° 30' 30" E, 77.80 feet;

THENCE S 23° 04' 59" E (deed S 24° 10' E), 111.95 feet continuing along said road to an angle point from which an iron rod set marked as before bears S 05° 06' 06" E, 61.79 feet;

THENCE S 29° 41' 56" E, 600.46 feet (deed S 30° 47' E, 600.40 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod marked as before bears S 13° 23' 06" E, 94.28 feet;

THENCE S 37° 04' 54" E, 253.01 feet (deed S 38° 10' E, 253.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod bears S 88° 03' 43" W, 51.26 feet;

THENCE S 15° 10' 06" E, 260.07 feet (deed S 16° 15' E, 260.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bears N 44° 55' 52" W, 63.82 feet;

THENCE S 24° 58' 48" W, 275.17 feet (deed S 23° 55' W, 275.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bearing S 78° 10" 38" W, 33.61 feet;

THENCE S 07° 29' 14" E, 151.05 feet (deed S 08° 34' W, 151.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bears S 88° 45' 42" W, 34.01 feet;

THENCE S 24° 31' 58" E, 1228.70 feet (deed S 25° 37' E, 1228.50 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set, marked as before bears S 27° 13' 45" W, 37.67 feet;

THENCE S 26° 25' 47" E, 743.72 feet (deed S 27° 31' E, 744.10 feet) continuing along said county road to the southeast corner of said Browning-Ferris, Inc. tract, said corner being in the northerly ROW line of the aforementioned F.M. Hwy. No. 66 from said corner, a 1/2 inch iron rod found bears S 48° 48' 49" W, 19.99 feet; said corner also being in a nontangent curve to the right whose radius is 2814.80 feet and whose long chord bears S 54° 47' 14" W, 558.29 feet (deed S 53° 45' 01" W, 558.29 feet);

THENCE along the southerly line of said Browning-Ferris, Inc. tract and along said northerly ROW line and along said curve to the right in a southwesterly direction through a central angle of 11° 22' 58" an arc length of 559.21 feet to a 1/2 inch iron rod found at the end of said curve, said iron rod being 5.6 feet southerly from a wire fence;

THENCE S 60° 28' 43" (deed S 59° 26' 30" W), 2,520.00 feet continuing along said southerly line of said Browning-Ferris, Inc. tract and along said highway ROW line to the POINT OF BEGINNING and containing 360.451 acres of land of which 2.558 acres of land lies within said county road running along the easterly side of said 360.451 acre tract.

Parcel 2:

65.307 acres of land situated in the Orlando Wheeler Survey, Abstract No. 949, Hill County, Texas, said 65.307 acres of land being a portion of a certain 66.359 acre tract described in a Lease Agreement to Browning Ferris, Inc. and recorded in Volume 645, Page 553, Hill County Deed Records, said 65.307 acres of land being more particularly described by metes and bounds as follows:

BEGINNING at a 5/8 inch iron rod found in the westerly ROW line and fence line of a gravel county road, said iron rod bears S 59° 57' W from an iron rod found in said county road, the southerly most southeast corner of said 66.359 acre lease tract;

THENCE S 59° 57' W 2491.91 feet along the southerly line of said lease tract to a 1" iron pipe found at the southwest corner of said lease tract;

THENCE N 26° 30' 57" W 902.71 feet along a fence line and along the west line of said least tract to a 1 3/4 inch iron pipe found S 26° 30' 57" E 37.4 feet from a fence corner;

THENCE N 59° 05' 30" E along the northerly line of said lease tract at approximatley 1080 feet passing near a fence angle point and continuing along and near a fence line in all 3214.86 feet to a 1/2 inch iron rod found at a fence corner once again in the westerly ROW line of the aforementioned county road, said iron rod bears S 59° 05' 30" W 26.0 feet from an iron rod in said county road, the northeast corner of said lease tract;

THENCE along said westerly ROW line and said westerly fence line of said county road the following courses and distances:

S 28° 30' 52" E 454.07 feet;

S 06 06' 42" E 12.23 feet;

S 19° 48' 18" W 188.76 feet;

S 09° 22' 36" W 341.01 feet;

S 55° 28" 26" W 352.19 feet;

S 04° 26' 51" W 86.73 feet to the POINT OF BEGINNING and containing 65.307 acres of land being all of the 66.359 acre lease tract previously mentioned above excluding 1.052 acres of land lying within the county road which had been included in said lease tract.

002124

FILED
AT 2:58 O'CLOCK P M
ON THE 14 DAY OF March
A.D., 20 02

Ruth Pelham
COUNTY CLERK, HILL CO. TEXAS

BY Sue McClure
DEPUTY

STATE OF TEXAS
COUNTY OF HILL
I hereby certify that this instrument was FILED on the date and at the time stamped hereon by me and was duly RECORDED in the Volume and Page of the Official Public Records of Hill County, Texas.

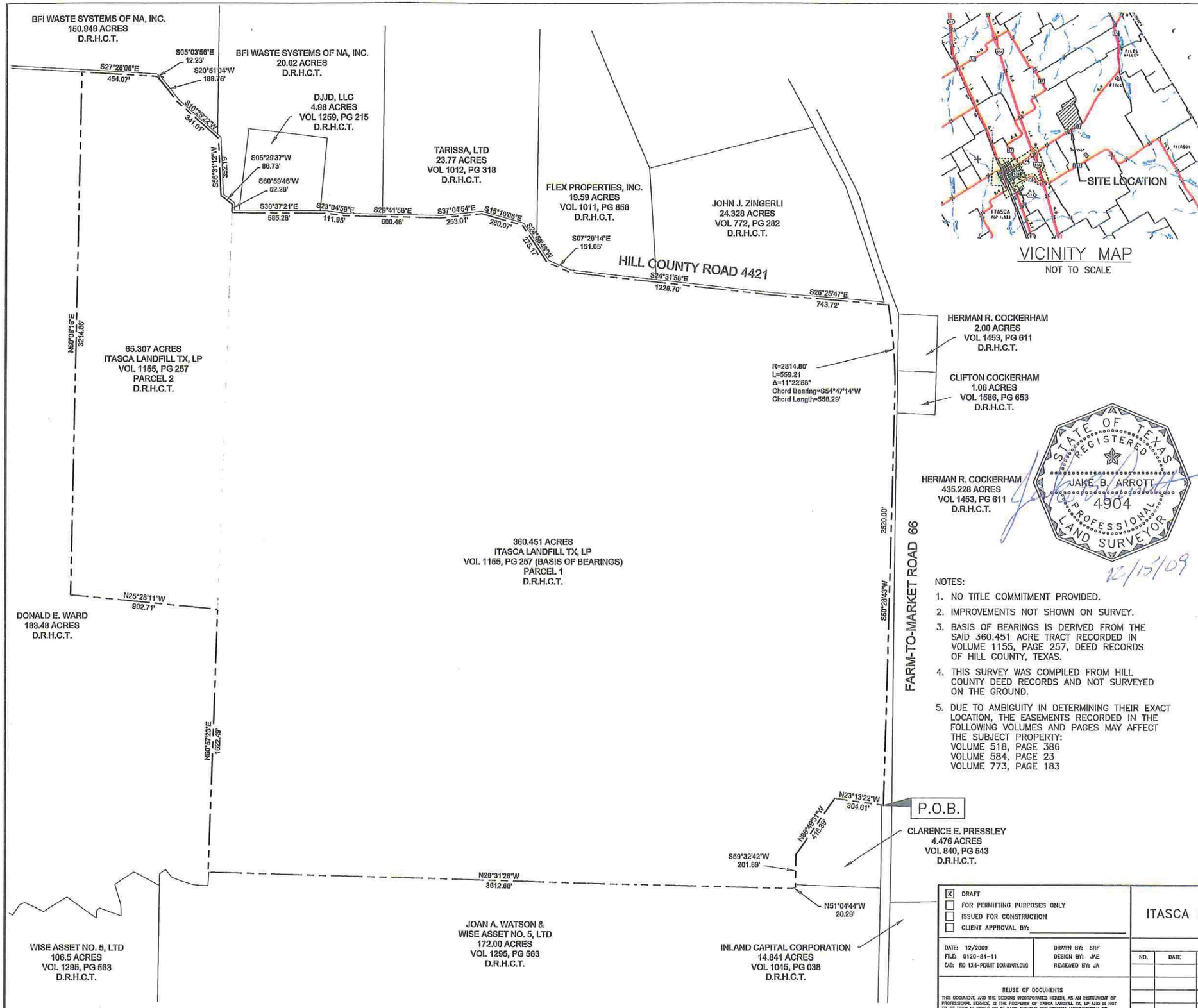
Ruth Pelham
County Clerk, Hill County, Texas

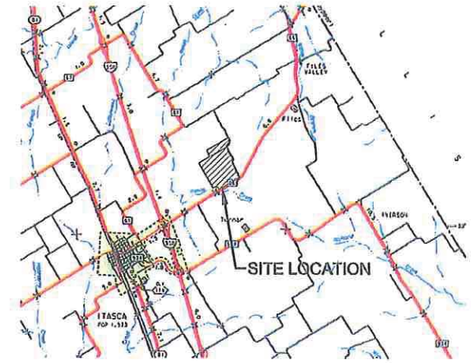
BY J. Hilton DEPUTY

RECORDED 3-14-2002

(Return to:
Stewart Title Int'l Marketing
1980 Post Oak BLVD STE. 610
Houston, TX. 77056)

OFF REC 1155 PAGE 0261





VICINITY MAP

NOT TO SCALE

0 300 600

SCALE IN FEET

LEGEND

PERMIT BOUNDARY

STATE OF TEXAS
REGISTERED
JAKE B. ARROTT
4904
PROFESSIONAL
LAND SURVEYOR

12/15/09

NOTES:

1. NO TITLE COMMITMENT PROVIDED.
2. IMPROVEMENTS NOT SHOWN ON SURVEY.
3. BASIS OF BEARINGS IS DERIVED FROM THE SAID 360.451 ACRE TRACT RECORDED IN VOLUME 1155, PAGE 257, DEED RECORDS OF HILL COUNTY, TEXAS.
4. THIS SURVEY WAS COMPILED FROM HILL COUNTY DEED RECORDS AND NOT SURVEYED ON THE GROUND.
5. DUE TO AMBIGUITY IN DETERMINING THEIR EXACT LOCATION, THE EASEMENTS RECORDED IN THE FOLLOWING VOLUMES AND PAGES MAY AFFECT THE SUBJECT PROPERTY:
   VOLUME 518, PAGE 386
   VOLUME 584, PAGE 23
   VOLUME 773, PAGE 183

METES AND BOUNDS DESCRIPTION

BEING a 425.758 acre tract situated in the ORLANDO WHEELER SURVEY, ABSTRACT No. 940, and being all of that certain 65.307 acre tract conveyed to Itasca Landfill TX, LP as recorded in Volume 1155, Page 257 of the Deed Records of Hill County, Texas, and being all of that certain 360.451 acre tract conveyed to Itasca Landfill TX, LP as recorded in Volume 1155, Page 257 of the Deed Records of Hill County, Texas, and being more particularly described by metes and bounds as follows:

BEGINNING at the southeast corner of that certain tract of land deeded to Clarence E. and wife Susie Pressley as recorded in Volume 840, Page 543 of the said deed records and being a corner of the said 360.451 acre tract, said point also being in the northwest line of Farm-to-Market Road 66;

THENCE along the boundary lines of the said 360.451 acre tract the following bearings and distances:
N 23°13'22" W, 304.61 feet;
N 86°49'31" W, 418.39 feet;
S 59°32'42" W, 201.89 feet;
N 51°04'44" W, 20.29 feet;
N 29°31'26" W, 3612.68 feet;
N 60°57'23" E, 1622.49 feet;

THENCE along the boundary lines of the said 65.307 acre tract the following bearings and distances:
N 25°28'11" W, 902.71 feet;
N 60°08'16" E, 3214.86 feet;
S 27°28'06" E, 454.07 feet;
S 05°03'56" W, 12.23 feet;
S 20°51'04" W, 188.76 feet;
S 10°25'22" W, 341.01 feet;
S 56°31'12" W, 352.19 feet;
S 05°29'37" W, 86.73 feet;
S 60°59'46" W, 52.28 feet;

THENCE along the boundary lines of the said 360.451 acre tract the following bearings and distances:
S 30°37'21" W, 585.28 feet;
S 23°04'59" E, 111.95 feet;
S 29°41'56" E, 600.46 feet;
S 37°04'54" E, 253.01 feet;
S 15°10'06" E, 260.07 feet;
S 24°58'48" W, 275.17 feet;
S 07°29'14" E, 151.05 feet;
S 24°31'58" E, 1228.70 feet;
S 26°25'47" E, 743.72 feet to the beginning of a non-tangent curve to the right;

THENCE 559.21 feet along the said curve to the right having a radius of 2814.80 feet, a central angle of 11°22'58", and a long chord which bears S 54°47'14" W, a distance of 558.29 feet;

THENCE S 60°28'43" W, 2520.00 feet to the POINT OF BEGINNING and containing 425.758 acres of land.

[X] DRAFT
[ ] FOR PERMITTING PURPOSES ONLY
[ ] ISSUED FOR CONSTRUCTION
[ ] CLIENT APPROVAL BY:

DATE: 12/2009
FILE: 0120-84-11
CAD: FIG 13.4-PERMIT BOUNDARY.DWG

DRAWN BY: SRF
DESIGN BY: JAE
REVIEWED BY: JA

REUSE OF DOCUMENTS

THIS DOCUMENT, AND THE DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF ITASCA LANDFILL TX, LP AND IS NOT TO BE USED IN WHOLE OR IN PART, WITHOUT THE WRITTEN AUTHORIZATION OF ITASCA LANDFILL TX, LP.

PREPARED FOR

ITASCA LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT

PERMIT BOUNDARY SURVEY
ITASCA LANDFILL
HILL COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO

FORT WORTH, TX
(817) 735-9770

GRIFFITH, IN
SOUTH BEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE I/II - 13.2

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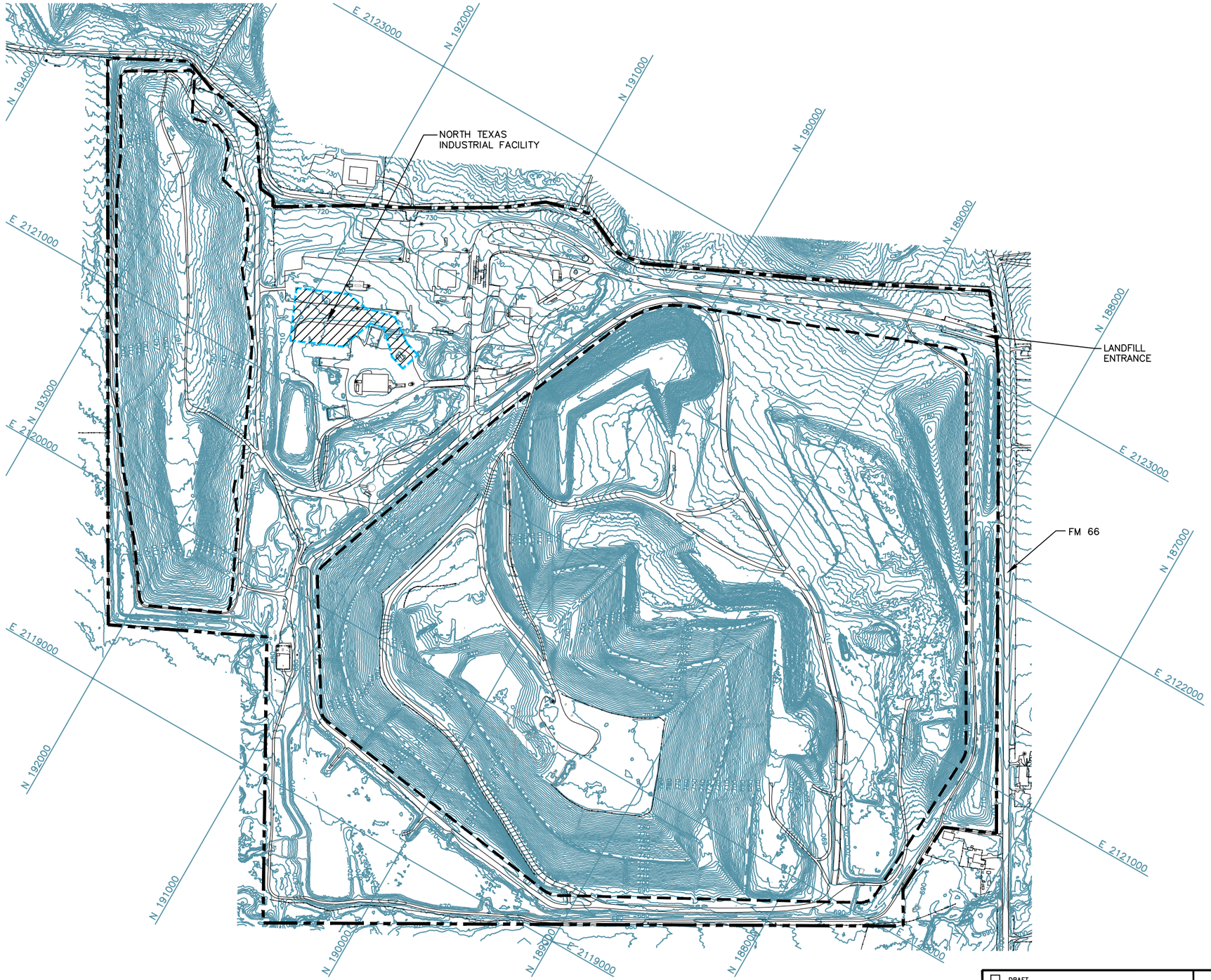
O:\0120\84\EXPANSION (2009)\PARTS I-II\Fig 13.4-Permit Boundary.dwg, sford, 1:2

ATTACHMENT D

ATTACHMENT D-1

OVERALL FACILITY PLOT



0 300 600
SCALE IN FEET

LEGEND

- ITASCA LANDFILL PROPERTY BOUNDARY
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PERMITTED LIMITS OF WASTE
- 730 — EXISTING CONTOUR
- N 188000 — STATE PLANE COORDINATE GRID

NOTES:

1. EXISTING CONTOURS PROVIDED BY FIRMATEK, LLC. FROM AERIAL PHOTOGRAPHY, FLOWN 11–06–2023.

☐ DRAFT
☒ ISSUED FOR PERMITTING PURPOSES
☐ FOR BIDDING PURPOSES ONLY

DATE: 06/2024
FILE: 0120–804–10
CAD: D–1–SITE PLAN.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: DP

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

NORTH TEXAS INDUSTRIAL FACILITY
INDUSTRIAL NONHAZARDOUS WASTE PERMIT
SITE PLAN

HILL COUNTY, TEXAS

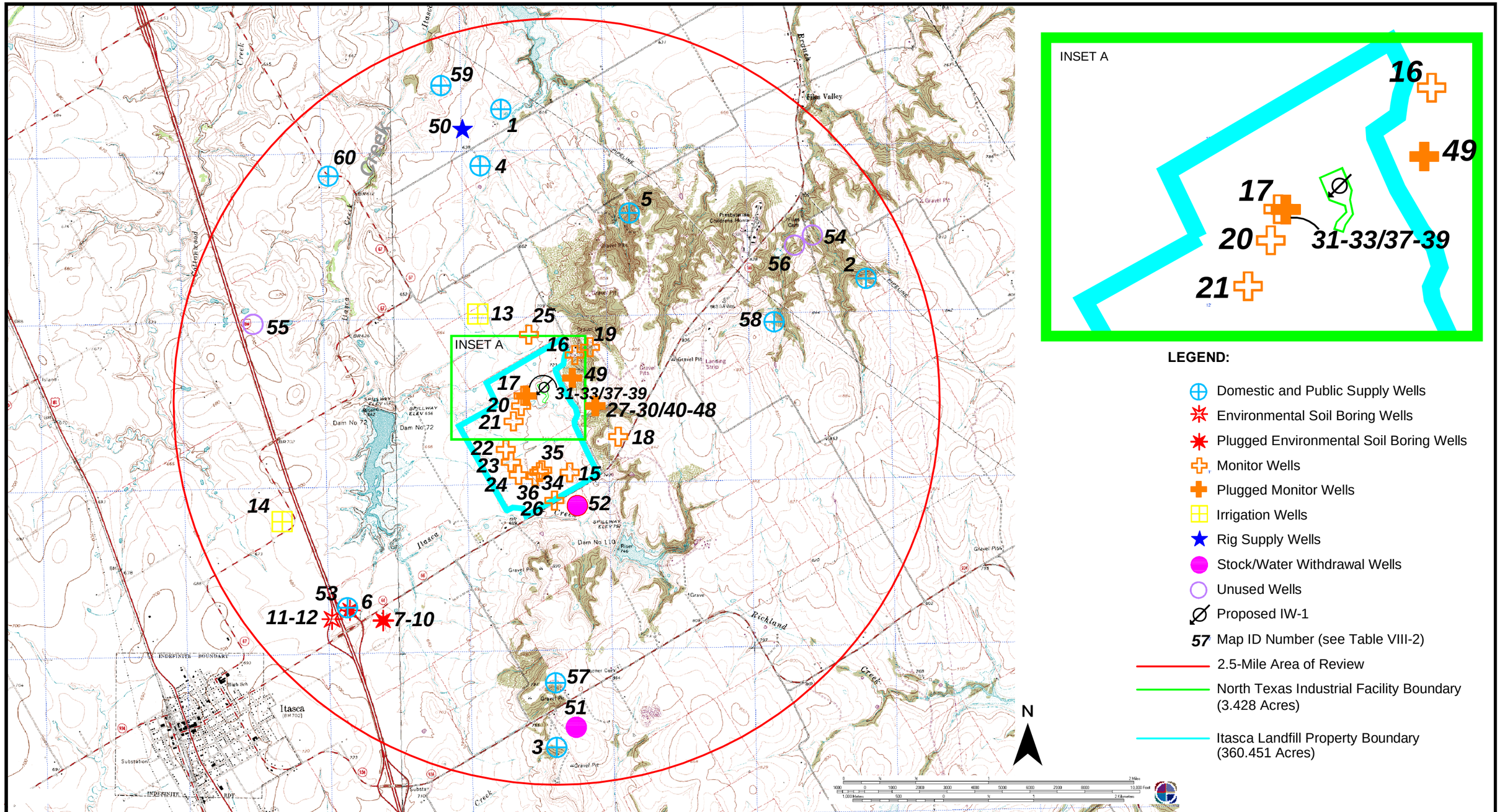
WWW.WCGRP.COM

ATTACHMENT D–1

O:\0120\804\WP PERMIT\ATT D–1–WSP Site Plan.dwg, sford, 1:2

ATTACHMENT D-2

TOPOGRAPHIC MAP AND WATER WELLS



WSP USA Inc.
16200 Park Row, Ste. 200
Houston, TX 77084
TEL: (281) 589-5900

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

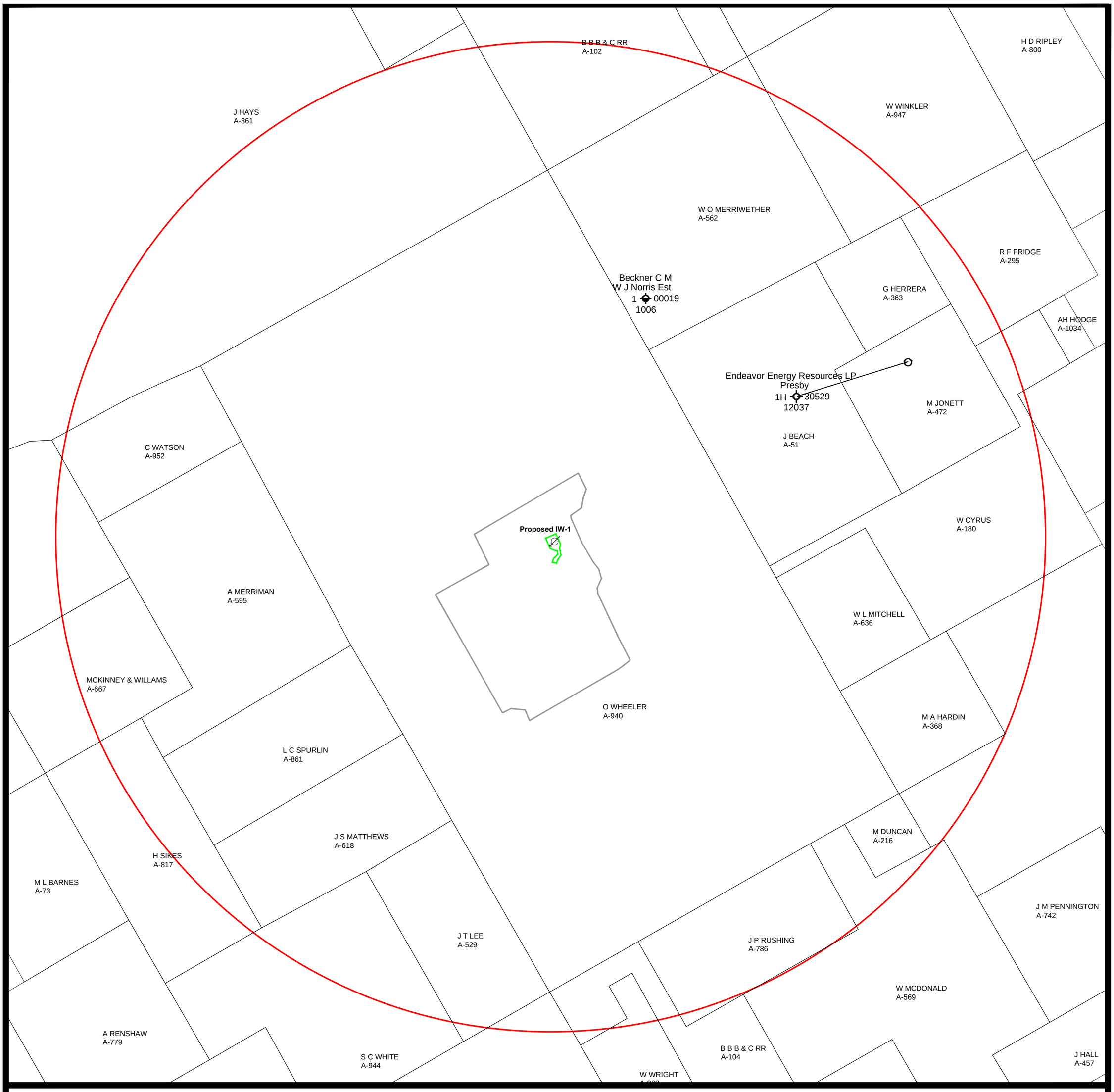
TOPOGRAPHIC MAP AND WATER WELLS

Job No. 192128M

Drawn:	Checked:	Approved:	Date:	Scale:	Attachment:
WDD	JT	GEM	06/10/2024	Above	D–2

ATTACHMENT D-3

AREA OF REVIEW MAP



-N-

API Number

Well Number

1H 30529
12037

Total Depth of Well

SCALE
(IN FEET)

0 2000 4000

LEGEND

- DRY HOLE
- DRY AND ABANDONED OIL
- BOTTOM HOLE LOCATION
- PROPOSED IW-1
- 2.5 MILE AREA OF REVIEW
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUNDARY

WSP USA Inc.
16200 Park Row, Ste. 200
Houston TX 77084
TEL: (281) 589-5900

ATTACHMENT D-3

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

AREA OF REVIEW MAP

DATE: 03/15/2021	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:

ATTACHMENT E

ATTACHMENT E

PLAIN LANGUAGE SUMMARY

Republic Industrial and Energy Solutions, LLC (RIES) is submitting a Class I Nonhazardous Injection Well Application to drill and operate one commercial injection well. RIES's Class I nonhazardous commercial well would allow for disposal of industrial wastewaters at the North Texas Industrial (NTI) Facility, located at 2559 FM 66 Itasca, Texas, 76055 in Hill County. The NTI Facility is a nonhazardous disposal facility which accepts municipal landfill leachate and Texas Class I and Class II industrial wastewaters.

The Class I injection well will utilize deep confined formations below the underground source of drinking water (USDW) to dispose of landfill leachate and other waste stream volumes delivered to the injection well not to exceed permitted volumes of 102,240 gallons per day or 37,343,160 gallons per year. The nonhazardous industrial waste streams received at the NTI Facility will consist of municipal landfill leachates, aqueous solutions that contain petroleum hydrocarbons and other contaminants below regulatory limits, and other aqueous wastes. Associated wastes include groundwater and rainfall contaminated by the authorized wastes, spills, wash waters and solutions used in cleaning and servicing the waste disposal well system equipment. This will also include wastes generated during the closure of the well and associated facilities.

RIES's proposed well will be constructed and drilled according to agency guidance and regulations. Testing of the injected waste with the formation fluid and minerals of both the Injection Zone and the Confining Zone will be conducted by a laboratory to ensure compatibility. The proposed well has been designed to 1) prevent the movement of fluids along the wellbore into or between USDWs, 2) prevent the movement of fluids along the wellbore out of the injection zone, 3) permit the use of appropriate testing devices and workover tools, and 4) permit continuous monitoring of injection tubing, long string casing and annulus. The length and quality of the surface casing is selected and designed to protect the lowermost USDW. The mechanical integrity of the long-string casing, injection tubing and annular seal will be tested upon completion of the well and annually by means of an approved pressure test with a liquid or a gas and whenever there has been a well workover. The integrity of the bottom-hole cement will be tested upon completion of the well and annually by means of an approved radioactive tracer survey and after workovers that have the potential to damage the cement within the injection zone. A temperature log, noise log or other approved log will be conducted upon completion of the well and at least once every five years to test for fluid movement along the borehole. Additionally, the wellhead and annulus pressures will be continuously monitored.

ANEXO E

RESUMEN EN LENGUAJE SENCILLO

Republic Industrial and Energy Solutions, LLC (RIES) está presentando una Solicitud de Pozo de Inyección No Peligroso Clase I para perforar y operar un pozo de inyección comercial. El pozo comercial de inyección de residuos no peligrosos Clase I de RIES permitiría la eliminación de aguas residuales industriales en las instalaciones de North Texas Industrial (NTI), ubicada en 2559 FM 66 Itasca, Texas, 76055 en el condado de Hill. La instalación NTI es una instalación de desechos no peligrosos, que acepta lixiviados de vertederos municipales y aguas residuales industriales de Clase I y Clase II de Texas.

El pozo de inyección Clase I utilizará formaciones profundas confinadas debajo de la fuente subterránea de agua potable (en inglés, Underground Source of Drinking Wáter, siglas USDW) para desechar los lixiviados de vertedero y otros volúmenes líquidos de desecho. Los desechos líquidos destinados al pozo de inyección no excederán los volúmenes permitidos de 102,240 galones por día o 37,343,160 galones por año. Los flujos de residuos industriales no peligrosos recibidos en la Instalación NTI consistirá en lixiviados de vertederos municipales, soluciones acuosas que contienen hidrocarburos de petróleo y otros contaminantes por debajo de los límites reglamentarios, y otros residuos acuosos. Otros desechos asociados incluyen las aguas subterráneas y de precipitaciones contaminadas por los desechos autorizados; incluyen derrames, aguas y soluciones utilizadas en la limpieza y el mantenimiento del equipo de pozos de eliminación de desechos. También incluirá los desechos generados durante el cierre del pozo y las instalaciones asociadas.

El pozo propuesto por RIES se construirá y perforará de acuerdo con las directrices y regulaciones de la agencia. Las pruebas de los residuos inyectados con el fluido de formación y los minerales tanto de la zona de inyección como de la zona de confinamiento se llevarán a cabo en un laboratorio para garantizar la compatibilidad. El pozo propuesto ha sido diseñado para 1) evitar el movimiento de fluidos a lo largo del pozo hacia o entre USDW, 2) evitar el movimiento de fluidos a lo largo del pozo fuera de la zona de inyección, 3) permitir el uso de dispositivos de prueba apropiados y herramientas de reacondicionamiento, y 4) permitir el monitoreo continuo de la tubería de inyección, de la tubería de revestimiento de cadena larga y del anular. La longitud y la calidad de la tubería de revestimiento de superficie se seleccionan y diseñan para proteger el USDW más bajo. La integridad mecánica de la tubería de revestimiento de cadena larga, la tubería de inyección y el sello anular se probarán al finalizar el pozo y anualmente por medio de una prueba de presión aprobada con un líquido o un gas y siempre que haya habido un reacondicionamiento del pozo. La integridad del cemento detrás de la tubería del pozo se corroborará al finalizar el pozo y anualmente con pruebas aprobadas, a través de un estudio de trazadores radiactivos; estas pruebas también se llevarán a cabo después de reparaciones con potencial de dañar el cemento dentro de la zona de inyección. Se llevará a cabo un registro de temperatura, un registro de ruido u otro registro aprobado al finalizar el pozo y al menos una vez cada cinco años para probar el movimiento de fluidos a lo largo del pozo. Además, se monitorearán continuamente las presiones de la boca del pozo y del anular.

ATTACHMENT F

Texas Commission on Environmental Quality

Public Involvement Plan Form for Permit and Registration Applications

The Public Involvement Plan is intended to provide applicants and the agency with information about how public outreach will be accomplished for certain types of applications in certain geographical areas of the state. It is intended to apply to new activities; major changes at existing plants, facilities, and processes; and to activities which are likely to have significant interest from the public. This preliminary screening is designed to identify applications that will benefit from an initial assessment of the need for enhanced public outreach.

All applicable sections of this form should be completed and submitted with the permit or registration application. For instructions on how to complete this form, see TCEQ-20960-inst.

Section 1. Preliminary Screening

☒ New Permit or Registration Application

☐ New Activity – modification, registration, amendment, facility, etc. (see instructions)

If neither of the above boxes are checked, completion of the form is not required and does not need to be submitted.

Section 2. Secondary Screening

☒ Requires public notice,

☐ Considered to have significant public interest, **and**

☐ Located within any of the following geographical locations:

- Austin
- Dallas
- Fort Worth
- Houston
- San Antonio
- West Texas
- Texas Panhandle
- Along the Texas/Mexico Border
- Other geographical locations should be decided on a case-by-case basis

If all the above boxes are not checked, a Public Involvement Plan is not necessary. Stop after Section 2 and submit the form.

☐ Public Involvement Plan not applicable to this application. Provide **brief** explanation.

Section 3. Application Information

Type of Application (check all that apply):

Air ☐ Initial ☐ Federal ☐ Amendment ☐ Standard Permit ☐ Title V

Waste ☐ Municipal Solid Waste ☐ Industrial and Hazardous Waste ☐ Scrap Tire
☐ Radioactive Material Licensing ☒ Underground Injection Control

Water Quality

☐ Texas Pollutant Discharge Elimination System (TPDES)

- ☐ Texas Land Application Permit (TLAP)
- ☐ State Only Concentrated Animal Feeding Operation (CAFO)
- ☐ Water Treatment Plant Residuals Disposal Permit

☐ Class B Biosolids Land Application Permit

☐ Domestic Septage Land Application Registration

Water Rights New Permit

☐ New Appropriation of Water

☐ New or existing reservoir

Amendment to an Existing Water Right

☐ Add a New Appropriation of Water

☐ Add a New or Existing Reservoir

☐ Major Amendment that could affect other water rights or the environment

Section 4. Plain Language Summary

Provide a brief description of planned activities.

See Attachment E

Section 5. Community and Demographic Information

Community information can be found using EPA's EJ Screen, U.S. Census Bureau information, or generally available demographic tools.

Information gathered in this section can assist with the determination of whether alternative language notice is necessary. Please provide the following information.

Itasca

(City)

Hill

(County)

Itasca CCD, Hill County, Texas
(Information was gathered on May 9th, 2024.)

(Census Tract)
Please indicate which of these three is the level used for gathering the following information.

☐ City ☐ County ☒ Census Tract

(a) Percent of people over 25 years of age who at least graduated from high school

87.9% received high school degrees and higher

(b) Per capita income for population near the specified location

$74,257 (families); $78,333 (married-couple families); $42,042 (nonfamily households)

(c) Percent of minority population and percent of population by race within the specified location

Total population - 4,236 including: American Indian & Alaska Native: 38 (0.9%); Asian: 29 (0.7%); Black or African American: 251 (5.9%); White: 2,937 (69.3%); Other: 518 (12.2%); Populations with two or more races: 463 (10.9%)

(d) Percent of Linguistically Isolated Households by language within the specified location

English only: 87.1%; Spanish: 11.4%; Other Indo-European language: 1%; Asian and Pacific Islander language: 0.4%; Other languages: 0.1%

(e) Languages commonly spoken in area by percentage

See language percentages in (d)

(f) Community and/or Stakeholder Groups

Information was not available on the US Census Bureau information tool for the Census Tract

(g) Historic public interest or involvement

Information was not available on the US Census Bureau information tool for the Census Tract

Section 6. Planned Public Outreach Activities

(a) Is this application subject to the public participation requirements of Title 30 Texas Administrative Code (30 TAC) Chapter 39?

☒ Yes ☐ No

(b) If yes, do you intend at this time to provide public outreach other than what is required by rule?

☐ Yes ☒ No

If Yes, please describe.

If you answered "yes" that this application is subject to 30 TAC Chapter 39, answering the remaining questions in Section 6 is not required.

(c) Will you provide notice of this application in alternative languages?

☒ Yes ☐ No

Please refer to Section 5. If more than 5% of the population potentially affected by your application is Limited English Proficient, then you are required to provide notice in the alternative language.

If yes, how will you provide notice in alternative languages?

☑ Publish in alternative language newspaper

☑ Posted on Commissioner's Integrated Database Website

☑ Mailed by TCEQ's Office of the Chief Clerk

☐ Other (specify)

(d) Is there an opportunity for some type of public meeting, including after notice?

☐ Yes ☒ No

(e) If a public meeting is held, will a translator be provided if requested?

☒ Yes ☐ No

(f) Hard copies of the application will be available at the following (check all that apply):

☐ TCEQ Regional Office ☐ TCEQ Central Office

☑ Public Place (specify)

Section 7. Voluntary Submittal

For applicants voluntarily providing this Public Involvement Plan, who are not subject to formal public participation requirements.

Will you provide notice of this application, including notice in alternative languages?

☐ Yes ☐ No

What types of notice will be provided?

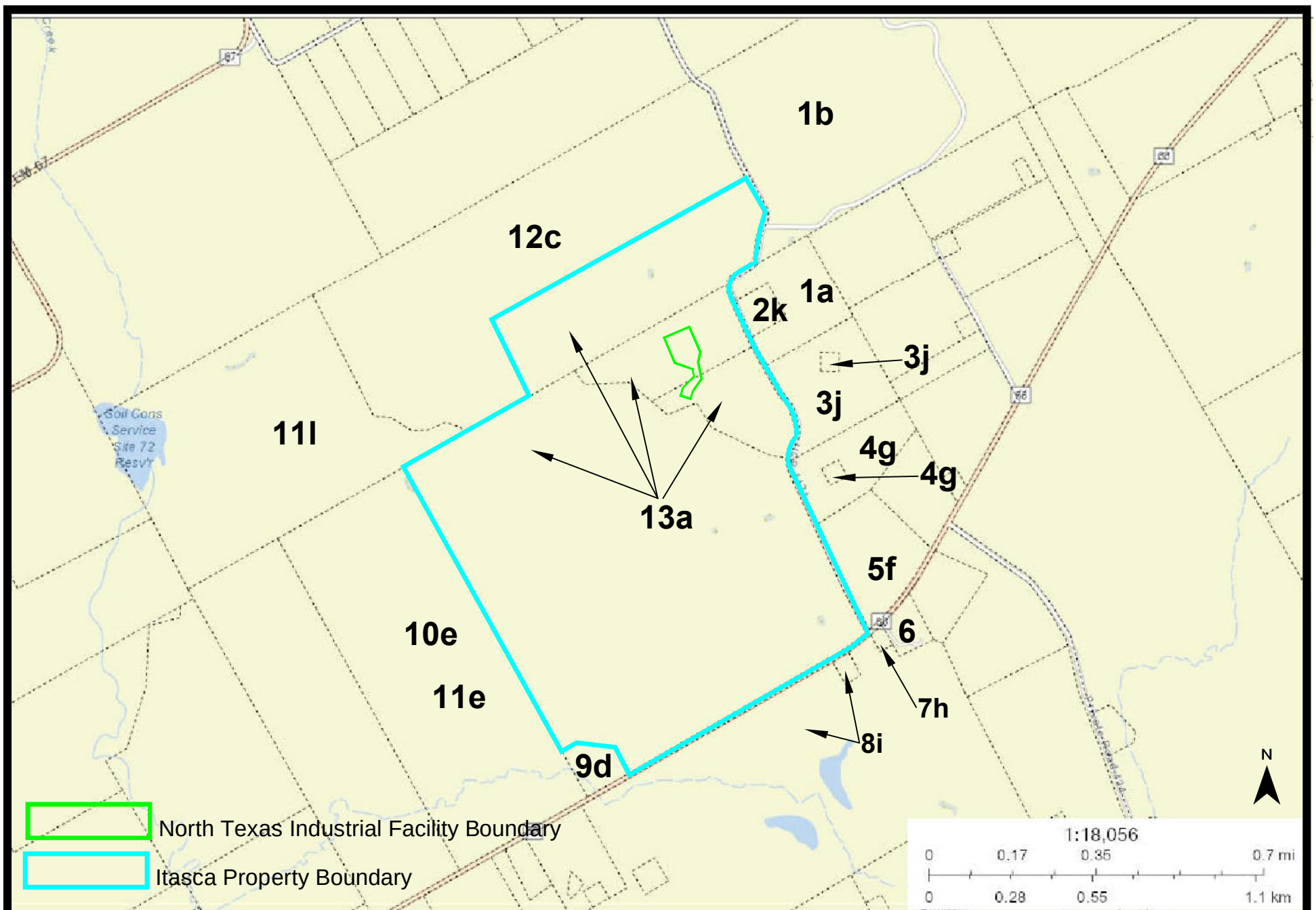
☐ Publish in alternative language newspaper

☐ Posted on Commissioner's Integrated Database Website

☐ Mailed by TCEQ's Office of the Chief Clerk

☐ Other (specify)

ATTACHMENT G



LIST OF ADJACENT LANDOWNERS AND MINERAL OWNERS

LAND OWNERS

1. BFI WASTE SYSTEMS OF NA INC
   PO BOX 29246
   PHOENIX AZ 85038
   (COMMERCIAL)

2. KILLEBREW MANAGEMENT INC
   PO BOX 930
   DRIPPING SPRINGS TX 78620
   (COMMERCIAL)

3. RICKY WATKINS
   PO BOX 782
   GRANDVIEW TX 76050
   (LAND/RESIDENTIAL)

4. J D KEATING & T M TOWERY
   22336 HOFFMAN RD
   MANDEVILLE LA 70471
   (LAND/RESIDENTIAL)

5. JOHN J ZINGERLI
   4501 S I-35 WEST
   ALVARADO TX 76009
   (LAND/AGRICULTURAL)

6. SHELLY BEAUMONT
   2580 FM 66
   ITASCA TX 76055
   (LAND/RESIDENTIAL)

7. GARY D & TAMMIE PRESSLEY
   2576 FM 66
   ITASCA TX 76055
   (RESIDENTIAL)

8. JOHN A COCKERHAM
   PO BOX 125
   ITASCA TX 76055
   (RESIDENTIAL AND PASTURE)

9. CLARENCE E PRESSLEY
   2421 FM 66
   ITASCA TX 76055
   (RESIDENTIAL)

10. JOAN A WATSON
    301 GREEN RIVER TRL
    FT WORTH TX 76109
    (NATIVE PASTURE/CROPLAND)

11. WISE ASSET NO 5 LTD
    6851 NE LOOP 820 STE 200
    N. RICHLAND HILLS TX 76180
    (NATIVE PASTURELAND)

12. EDWIN L COCKERHAM
    605 E SOUTH ST
    ITASCA TX 76055
    (NATIVE PASTURELAND)

13. ITASCA LANDFILL TX LP
    P O BOX 29246
    PHOENIX AZ 85038-9246
    (COMMERCIAL)

MINERAL OWNERS

a. ITASCA LANDFILL TX LP
   P. O. BOX 29246
   PHOENIX, AZ 85036

a. JANIE C. BAKER
   501 N. KING ST.
   ITASCA, TX 76055-2227

a,b,c
   JEANINE J. KLEIN
   1577 SKYLINE DR.
   LAGUNA BEACH, CA 92651

b . BFI WASTE SYSTEMS OF N AM, INC.
   P O BOX 29246
   PHOENIX, AZ 85036

b,f,g,j,k
   DEBRA KAREN SCOTT
   3917 FM 67
   ITASCA, TX 76055

b,f,g,j,k
   PEGGY W. SUMNER
   4508 UNIVERSITY BLVD.
   DALLAS, TX 75205

b,f,g,j,k
   KATHY FOWLER
   1776 BARLOW AVENUE NW
   SALEM, OR 97304

b,f,g,j,k
   GWEN SUMNER
   5010 LAKE SHORE DR.
   WACO, TX

b,f,g,j,k
   DAVID MILLER SCOTT
   1776 BARLOW AVENUE NW
   SALEM, OR 97304

b,f,g,j,k
   JANE GOODE
   4824 LAKESIDE DRIVE
   COLLEYVILLE, TX 76043

b,f,g,j,k
   HATTON W. SUMNER
   11808 BLUE SAGE RD.
   OKLAHOMA CITY, OK 73120

b,f,g,j,k
   MINTHA DORIS SUMNER
   407 S. COLLEGE ST.
   ITASCA, TX 76055

b,f,g,j,k
   LAURIE MILES
   3917 FM 67
   ITASCA, TX 76055

b,f,g,j,k
   DIANE SUMNER BARNES
   404 N. MONROE
   ITASCA, TX 76055

b,f,g,j,k
   WANDA R. SUMNER
   200 WALNUT HILL AVE. UNIT 30
   HILLSBORO, TX 76645

c. EDWIN LEON COCKERHAM
   605 E SOUTH ST
   ITASCA, TX 76055

d. CLARENCE E. AND SUSIE PRESSLEY
   2421 FM 66
   ITASCA, TX 76055

e. JOANNE A WATSON
   4718 O'CONNOR CT.
   IRVING, TX 75062

e,l
   WISE ASSET NO. 5 LTD.
   6851 NE LOOP 820, SUITE 200
   NORTH RICHLAND HILLS, TX 76180

f. BETTY L . ZINGERLI
   4501 SO. I-35 WEST
   ALVARADO, TX 76009

g. J. D. KEATING AND T. M. TOWEREY
   22336 HOFFMAN RD.
   MANDEVILLE LA 70741

h. GARY D. AND TAMMIE PRESSLEY
   2578 FM 66
   ITASCA, TX 76055

h. AETNA LIFE INSURANCE COMPANY
   ATT: JEFFREY R. DIGEL, VP
   151 FARMINGTON AVE.
   HARTFORD, CN 06561-9642

i. JOHN A. COCKERHAM
   P. O. BOX 125
   ITASCA, TX 76055

i. JERRY R. COCKERHAM
   243 HCR 4247
   HILLSBORO, TX 76645

j. RICKY WATKINS
   P. O. BOX 782
   GRANVIEW, TX 76050

k. KILLEBREW MANAGEMENT, INC.
   P. O. BOX 930
   DRIPPING SPRINGS, TX 78620

* See https://www.sec.gov/Archives/edgar/data/1060391/000106039120000016/exhibit211-subsidiarie.htm for listing of Republic subsidiaries and affiliates

WSP USA Inc.
8212 Kelwood Ave.
Baton Rouge, LA 70806
TEL: (225) 753-2561

ATTACHMENT G

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

ADJACENT LANDOWNERS MAP

DATE: 06/10/24	CHECKED BY: CMC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: MEC	DWG. NO:

List of Mineral Owners Under Itasca Landfill and Adjacent Tracts

TRACT NO.	NAME	ADDRESS	CITY STATE ZIP	GROSS ACRES	REMARKS
1	Janie C. Baker	501 N. King St.	Itasca, TX 76055-2227	360.451	Wife of Ollie Baker
1	Itasca Landfill TX LP	P. O. Box 29246	Phoenix, AZ 85036	360.451	
1	Itasca Landfill TX LP	P. O. Box 29246	Phoenix, AZ 85036	66.345	Jeanine J. Klein owns an undivided ohe-half mineral interest in this tract. See below.
1	Jeanine J. Klein	1577 Skyline Dr.	Laguna Beach, CA 92651	66.345	Mineral reservation by Lucille Lawson Head in Vol. 436, pg. 265 Deed Records of Hill County, Texas. This mineral interest covers portions of Tr. 1, 2 and 3
2	BFI Waste Systems of North America, Inc.	P. O. Box 29246	Phoenix, AZ 85036	150.949	The Lucille Lawson Head interest covers approximately the southern half of this tract. Her interest is approximately 37.7372 net mineral acres.
2	Jeanine J. Klein	1577 Skyline Dr.	Laguna Beach, CA 92651	75.475	This interest covers approximately the south half of the 159.949 acre tract.
2	BFI Waste Systems of North America, Inc.	P. O. Box 29246	Phoenix, AZ 85036	20.020	Eva Sumner's heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11
2	Mintha Doris Sumner	407 S. College St.	Itasca, TX 76055	20.020	1/2 of 1/7th interest . Eva Sumner heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11 Diane is her daughter
2	Diane Sumner Barnes	404 N. Monroe	Itasca, TX 76055	20.020	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2, and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
2	Debra Karen Scott	3917 FM 67	Itasca, TX 76055	20.020	817-939-1114 David 817-929-1066 Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
2	Kathy Fowler	1776 Barlow Avenue NW	Salem, OR 97304	20.020	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
2	David Miller Scott	1776 Barlow Avenue NW	Salem, OR 97304	20.020	Husband of Daughter of Louise Sumner McCauley, Kathy Fowler 1/4 of 1/7 of 1/2
2	Hatton W. Sumner	11808 Blue Sage Rd.	Oklahoma City, OK 73120	20.020	Grandson of Eva Sumner 1/7 of 1/2 and Nephew of Betty Joyce Sumner 1/5 of 1/7 of 1/2

List of Mineral Owners Under Itasca Landfill and Adjacent Tracts

TRACT NO.	NAME	ADDRESS	CITY STATE ZIP	GROSS ACRES	REMARKS
2	Laurie Miles	3917 FM 67	Itasca, TX 76055	20.020	(253) 770-8777Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2
2	Wanda R. Sumner	200 Walnut Hill Ave. Unit 30	Hillsboro, TX 76645	20.020	Wife of Garvin K. Sumner 1/2 of 1/7
2	Peggy W. Sumner	4508 University Blvd.	Dallas, TX 75205	20.020	Wife of Donald Sumner 1/2 of 1/7 of 1/2
2	Gwen Sumner	5010 Lake Shore Dr.	Waco, TX	20.020	Wife of David Sumner 1/2 of 1/7 of 1/2
2	Jane Goode	4824 Lakeside Dr.	Colleyville, TX 76043	24.770	Sister-in-law of Frank Lee Lasseter, who died in Dallas County, Texas. She appears to be the only heir of Frank's wife, Leta, who died after Frank. No probate information has been filed on Frank or Leta Lassetter.
3	Edwin Leon Cockerham	605 E South St	Itasca, TX 76055	183.480	Mineral acreage count is estimated. The Lucille Klein interest covers approximately 8.18 acres of this tract. Her interest is approximately 4.09 net mineral acres.
3	Jeanine J. Klein	1577 Skyline Dr.	Laguna Beach, CA 92651	8.180	Mineral reservation by Lucille Lawson Head in Vol. 436, pg. 265 Deed Records of Hill County, Texas. This mineral interest covers portions of Tracts 1, 2 and 3.
4	Clarence E. Pressley and wife, Susie Pressley	2421 FM 66	Itasca, TX 76055	4.476	Owns all surface and minerals.
5	Wise Asset No. 5 Ltd.	6851 NE Loop 820, Suite 200	North Richland Hills, TX 76180	170.960	Owns 1/2 surface and 1/2 minerals
5	Joanne A Watson	4718 O'Connor Ct.	Irving, TX 75062	170.960	Owns 1/2 surface and 1/2 minerals
6	Betty L . Zingerli	4501 So. I-35 West	Alvarado, TX 76009	24.328	Owns all surface and 1/2 minerals
6	Mintha Doris Sumner	407 S. College St.	Itasca, TX 76055	24.328	1/2 of 1/7th interest . Eva Sumner heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11 Diane is her daughter
6	Diane Sumner Barnes	404 N. Monroe	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2, and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
6	Debra Karen Scott	3917 FM 67	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
6	Kathy Fowler	1776 Barlow Avenue NW	Salem, OR 97304	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2

List of Mineral Owners Under Itasca Landfill and Adjacent Tracts

TRACT NO.	NAME	ADDRESS	CITY STATE ZIP	GROSS ACRES	REMARKS
6	David Miller Scott	1776 Barlow Avenue NW	Salem, OR 97304	24.328	Husband of Daughter of Louise Sumner McCauley, Kathy Fowler 1/4 of 1/7 of 1/2
6	Hatton W. Sumner	11808 Blue Sage Rd.	Oklahoma City, OK 73120	24.328	Grandson of Eva Sumner 1/7 of 1/2 and Nephew of Betty Joyce Sumner 1/5 of 1/7 of 1/2
6	Laurie Miles	3917 FM 67	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2
6	Wanda R. Sumner	200 Walnut Hill Ave. Unit 30	Hillsboro, TX 76645	24.328	Wife of Garvin K. Sumner 1/2 of 1/7
6	Peggy W. Sumner	4508 University Blvd.	Dallas, TX 75205	24.328	Wife of Donald Sumner 1/2 of 1/7 of 1/2
6	Gwen Sumner	5010 Lake Shore Dr.	Waco, TX	24.328	Wife of David Sumner 1/2 of 1/7 of 1/2
6	Jane Goode	4824 Lakeside Dr.	Colleyville, TX 76043	24.770	Sister-in-law of Frank Lee Lasseter, who died in Dallas County, Texas. She appears to be the only heir of Frank's wife, Leta, who died after Frank. No probate information has been filed on Frank or Leta Lassetter.
7	J. D. Keating and T. M. Towery	22336 Hoffman R.	Mandeville, LA 70471	20.000	Owns all surface and 1/2 minerals
7	Mintha Doris Sumner	407 S. College St.	Itasca, TX 76055	24.328	1/2 of 1/7th interest . Eva Sumner heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11 Diane is her daughter
7	Diane Sumner Barnes	404 N. Monroe	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2, and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
7	Debra Karen Scott	3917 FM 67	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
7	Kathy Fowler	1776 Barlow Avenue NW	Salem, OR 97304	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
7	David Miller Scott	1776 Barlow Avenue NW	Salem, OR 97304	24.328	Husband of Daughter of Louise Sumner McCauley, Kathy Fowler 1/4 of 1/7 of 1/2
7	Hatton W. Sumner	11808 Blue Sage Rd.	Oklahoma City, OK 73120	24.328	Grandson of Eva Sumner 1/7 of 1/2 and Nephew of Betty Joyce Sumner 1/5 of 1/7 of 1/2
7	Laurie Miles	3917 FM 67	Itasca, TX 76055	24.328	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2
7	Wanda R. Sumner	200 Walnut Hill Ave. Unit 30	Hillsboro, TX 76645	24.328	Wife of Garvin K. Sumner 1/2 of 1/7
7	Peggy W. Sumner	4508 University Blvd.	Dallas, TX 75205	24.328	Wife of Donald Sumner 1/2 of 1/7 of 1/2

List of Mineral Owners Under Itasca Landfill and Adjacent Tracts

TRACT NO.	NAME	ADDRESS	CITY STATE ZIP	GROSS ACRES	REMARKS
7	Gwen Sumner	5010 Lake Shore Dr.	Waco, TX	24.328	Wife of David Sumner 1/2 of 1/7 of 1/2
7	Jane Goode	4824 Lakeside Dr.	Colleyville, TX 76043	24.770	Sister-in-law of Frank Lee Lasseter, who died in Dallas County, Texas. She appears to be the only heir of Frank's wife, Leta, who died after Frank. No probate information has been filed on Frank or Leta Lassetter.
8	Gary D. Pressley and Tammie Pressley	2578 FM 66	Itasca, TX 76055	1.250	Owns all surface and 3/4 minerals
8	Aetna Life Insurance Company, Attention: Jeffrey R. Digel, Vice President	151 Farmington Ave.	Hartford, CN 06561-9642	1.250	Owns 1/4 minerals by virtue of mineral reservation in Deed conveying 100.0 acres in 2 tracts from Aetna to Paul Reese in 304/423 Deed records of Hill County, Texas.
9	John A. Cockerham	P. O. Box 125	Itasca, TX 76055	377.976	Owns all of the surface and 1/2 minerals, except for 100 acres in 2 tracts in which Aetna owns 1/4 minerals.
9	Jerry R. Cockerham	243 HCR 4247	Hillsboro, TX 76645	377.976	1/2 minerals, except for 100 acres in 2 tracts in which Aetna owns 1/4 minerals.
10	Ricky Watkins	P. O. Box 782	Granview, TX 76050	24.770	Owns all surface and 1/2 minerals
10	Mintha Doris Sumner	407 S. College St.	Itasca, TX 76055	24.770	1/2 of 1/7th interest . Eva Sumner heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11 Diane is her daughter
10	Diane Sumner Barnes	404 N. Monroe	Itasca, TX 76055	24.770	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2, and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
10	Debra Karen Scott	3917 FM 67	Itasca, TX 76055	24.770	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
10	Kathy Fowler	1776 Barlow Avenue NW	Salem, OR 97304	24.770	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
10	David Miller Scott	1776 Barlow Avenue NW	Salem, OR 97304	24.770	Husband of Daughter of Louise Sumner McCauley, Kathy Fowler 1/4 of 1/7 of 1/2
10	Hatton W. Sumner	11808 Blue Sage Rd.	Oklahoma City, OK 73120	24.770	Grandson of Eva Sumner 1/7 of 1/2 and Nephew of Betty Joyce Sumner 1/5 of 1/7 of 1/2
10	Laurie Miles	3917 FM 67	Itasca, TX 76055	24.770	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2
10	Wanda R. Sumner	200 Walnut Hill Ave. Unit 30	Hillsboro, TX 76645	24.770	Wife of Garvin K. Sumner 1/2 of 1/7

List of Mineral Owners Under Itasca Landfill and Adjacent Tracts

TRACT NO.	NAME	ADDRESS	CITY STATE ZIP	GROSS ACRES	REMARKS
10	Peggy W. Sumner	4508 University Blvd.	Dallas, TX 75205	24.770	Wife of Donald Sumner 1/2 of 1/7 of 1/2
10	Gwen Sumner	5010 Lake Shore Dr.	Waco, TX	24.770	Wife of David Sumner 1/2 of 1/7 of 1/2
10	Jane Goode	4824 Lakeside Dr.	Colleyville, TX 76043	24.770	Sister-in-law of Frank Lee Lasseter, who died in Dallas County, Texas. She appears to be the only heir of Frank's wife, Leta, who died after Frank. No probate information has been filed on Frank or Leta Lassetter.
11	Killebrew Management, Inc.	P. O. Box 930	Dripping Springs, TX 78620	4.980	Owns all surface and 1/2 minerals
11	Mintha Doris Sumner	407 S. College St.	Itasca, TX 76055	4.980	1/2 of 1/7th interest . Eva Sumner heirs own an undivided one-half mineral interest in this tract. Her mineral interest covers a portion of Tract 2, and all of Tracts 6,7,10 and 11 Diane is her daughter
11	Diane Sumner Barnes	404 N. Monroe	Itasca, TX 76055	4.980	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2, and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
11	Debra Karen Scott	3917 FM 67	Itasca, TX 76055	4.980	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
11	Kathy Fowler	1776 Barlow Avenue NW	Salem, OR 97304	4.980	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2 and Daughter of Louise Sumner McCauley 1/4 of 1/7 of 1/2
11	David Miller Scott	1776 Barlow Avenue NW	Salem, OR 97304	4.980	Husband of Daughter of Louise Sumner McCauley, Kathy Fowler 1/4 of 1/7 of 1/2
11	Hatton W. Sumner	11808 Blue Sage Rd.	Oklahoma City, OK 73120	4.980	Grandson of Eva Sumner 1/7 of 1/2 and Nephew of Betty Joyce Sumner 1/5 of 1/7 of 1/2
11	Laurie Miles	3917 FM 67	Itasca, TX 76055	4.980	Niece of Betty Joyce Sumner 1/5 of 1/7 of 1/2
11	Wanda R. Sumner	200 Walnut Hill Ave. Unit 30	Hillsboro, TX 76645	4.980	Wife of Garvin K. Sumner 1/2 of 1/7
11	Peggy W. Sumner	4508 University Blvd.	Dallas, TX 75205	4.980	Wife of Donald Sumner 1/2 of 1/7 of 1/2
11	Gwen Sumner	5010 Lake Shore Dr.	Waco, TX	4.980	Wife of David Sumner 1/2 of 1/7 of 1/2
11	Jane Goode	4824 Lakeside Dr.	Colleyville, TX 76043	24.770	Sister-in-law of Frank Lee Lasseter, who died in Dallas County, Texas. She appears to be the only heir of Frank's wife, Leta, who died after Frank. No probate information has been filed on Frank or Leta Lassetter.
12	Wise Asset No. 5 Ltd.	6851 NE Loop 820, Suite 200	North Richland Hills, TX 76180	103.910	Owns all surface and all minerals.

ATTACHMENT H

Our ref.: 192128M

January 4, 2023

Environmental Services
Oil and Gas Division
Railroad Commission of Texas
1701 N. Congress
Austin, Texas 78701

Subject: Permit Application Class I Nonhazardous Injection Well – North Texas Industrial Facility, Itasca, Hill County, Texas

Dear Sir/Madam:

On behalf of Republic Industrial and Energy Solutions, LLC (Republic), WSP USA is submitting a copy of the permit application for one proposed Class I nonhazardous injection wells at its North Texas Industrial Facility located in Itasca, Texas for your review. As required by the Texas Commission on Environmental Quality (TCEQ), Republic requests that the Railroad Commission of Texas issue a letter to Republic that states that "injecting industrial waste into the subsurface stratum will not endanger or injure any known oil or gas resources." Your letter will be included in Section III of the permit application to TCEQ.

Pursuant to this request, one copy of the permit application document that was submitted to the TCEQ is enclosed with this letter. The requested injection interval is in the Ellenburger Formation described in Section V of the application.

If you have any questions regarding this information, please contact Gary McCuistion of Republic at 832-399-4516 (GMcCuistion@republicservices.com).

Kind regards,

Morgan Canezaro
Project Manager, UIC Lead

Encl.
cc: Gary McCuistion (Republic); Carol Dye (TCEQ)

WSP USA
Suite 200
16200 Park Row
Houston, TX 77084

Tel.: +1 281 589-5900
Fax: +1 281 759-5164
wsp.com

ATTACHMENT I

PERFORMANCE BOND

Date bond executed: October 16, 2023.

Effective date: October 31, 2023.

Principal: Republic Industrial and Energy Solutions, LLC, 2559 FM 66, Itasca, TX 76055.

Type of organization: Limited Liability Company.

State of incorporation: Delaware.

Surety(ies): Evergreen National Indemnity Company, 6150 Oak Tree Blvd., Ste 440, Independence, OH 44131.

Permit number, name, physical and mailing addresses, and closure, post closure, or corrective action amounts(s) for each facility guaranteed by this bond:

Permit#: SWR 86925 / Itasca Deep Well
Name: Republic Industrial and Energy Solution, LLC
Physical Address: 2559 FM 66, Itasca, TX 76055
Mailing Address: 10613 W. Sam Houston Parkway N., Ste 300 Houston, TX 77064
Closure Amount: $526,478.00

Total penal sum of bond: $ 526,478.00.

Surety's bond number: 880377.

Know All Persons By These Presents, That We, the Principal and Surety(ies) hereto are firmly bound to the Texas Commission on Environmental Quality, hereinafter called TCEQ, in the above penal sum for the payment of which we bind ourselves, our heirs, executors, administrators, successors, and assigns jointly and severally; provided that, where the Surety(ies) are corporations acting as co-sureties, we, the Sureties, bind ourselves in such sum "jointly and severally" only for the purpose of allowing a joint action or actions against any or all of us, and for all other purposes each Surety binds itself, jointly and severally with the Principal, for the payment of such sum only as is set forth opposite the name of such Surety, but if no limit of liability is indicated, the limit of liability shall be the full amount of the penal sum.

Whereas said Principal is required, under the appropriate program area, to comply with permit requirements in order to own or operate each facility identified above, and

Whereas said Principal is required to provide financial assurance for closure, post closure, or corrective action as a condition of the permit or other applicable requirements, and

Whereas said Principal shall establish a standby trust fund as is required when a surety bond is used to provide such financial assurance;

Now, therefore, the conditions of this obligation are such that if the Principal shall faithfully perform closure, post closure, or corrective action, whenever required to do so, of each facility for which this bond guarantees closure or post closure in accordance with the closure plan or post closure plan and other applicable requirements of the permit, or perform corrective action in accordance with the

permit or other applicable requirements as may be amended, pursuant to all applicable laws, statutes, rules and regulations, as such laws, statutes, rules, and regulations may be amended,

Or, if the Principal shall provide alternate financial assurance, as specified in 30 Texas Administrative Code, Chapter 37 (relating to Financial Assurance) and obtain the TCEQ executive director's written approval of such assurance, within 90 days after the date of notice of cancellation is received by both the Principal and the TCEQ executive director from the Surety(ies), then this obligation shall be null and void, otherwise it is to remain in full force and effect.

The Surety(ies) shall become liable on this bond obligation only when the Principal has failed to fulfill the conditions described above.

Upon notification by the TCEQ executive director that the Principal has been found in violation of the closure, post closure, or corrective action requirements for a facility for which this bond guarantees performance of closure, post closure, or corrective action, the Surety(ies) shall either perform closure, post closure, or corrective action in accordance with the closure plan or post closure plan and other applicable requirements of the permit, or perform corrective action in accordance with the permit or other applicable requirements, or place the amount guaranteed for the facility in the standby trust fund as directed by the TCEQ executive director.

Upon notification by the TCEQ executive director that the Principal has failed to provide alternate financial assurance, as specified in 30 Texas Administrative Code, Chapter 37, and obtain written approval of such assurance from the TCEQ executive director during the 90 days following receipt by both the Principal and the TCEQ executive director of a notice of cancellation of the bond, the Surety(ies) shall place funds in the amount guaranteed for the facility(ies) into the standby trust fund.

The surety(ies) hereby waive(s) notification of amendments to closure plans or post closure plans and other applicable requirements of the permit, or permits requiring corrective action or other applicable requirements for corrective action, applicable laws, statutes, rules, and regulations and agrees that no such amendment shall in any way alleviate its (their) obligation on this bond.

The liability of the Surety(ies) shall not be discharged by any payment or succession of payments hereunder, unless and until such payment or payments shall amount in the aggregate to the penal sum of the bond, but in no event shall the obligation of the Surety(ies) hereunder exceed the amount of said penal sum.

The Surety(ies) may cancel the bond by sending notice of cancellation by certified mail to the owner and operator and to the TCEQ executive director provided, however, that cancellation shall not occur during the 120 days beginning on the date of receipt of the notice of cancellation by both the Principal and the TCEQ executive director, as evidenced by the return receipts.

The principal may terminate this bond by sending written notice to the Surety(ies), provided, however, that no such notice shall become effective until the Surety(ies) receive(s) written authorization for termination of the bond by the TCEQ executive director.

Principal and Surety(ies) hereby agree to adjust the penal sum of the bond yearly so that it guarantees a new closure, post closure, or corrective action amount, provided that the penal sum does

not increase by more than 20 percent in any one year, and no decrease in the penal sum takes place without the written permission of the TCEQ executive director.

In Witness Whereof, The Principal and Surety(ies) have executed this Performance Bond and have affixed their seals on the date set forth above.

The persons whose signatures appear below hereby certify that they are authorized to execute this surety bond on behalf of the Principal and Surety(ies) and that the wording on this surety bond is identical to the wording specified in 30 Texas Administrative Code § 37.321 as such regulation was constituted on the date this bond was executed.

Principal

(Signature(s))_____

(Name(s)) Amber Engel

(Title(s)) Attorney-in-Fact

(Corporate seal)

(Corporate Surety(ies))

(Name and address) Evergreen National Indemnity Company 6150 Oak Tree Blvd., Ste 440 Independence, OH 44131

State of Incorporation: Ohio

Liability limit: $ 526,478.00

(Signature(s))_____

(Name(s) and title(s)) Debbie Lindstrom, Attorney-in-Fact

(Corporate seal)

Bond premium: $ 4,212.00

REPUBLIC SERVICES

POWER OF ATTORNEY

REPUBLIC SERVICES, INC., a Delaware corporation having its principal place of business at 18500 N. Allied Way, Phoenix, Arizona 85054, hereby makes, constitutes and appoints KIBBLE & PRENTICE HOLDING COMPANY dba USI INSURANCE SERVICES NORTHWEST, acting through and by any one of Debbie Lindstrom, Kathleen M. Mitchell, Scott C. Alderman, Amber Engel, Jamie Armfield, Holly E. Ulfers, or Roxana Palacios, its true and lawful attorney to sign and seal any and all surety bonds, bid bonds, performance bonds and payment bonds at or below the monetary threshold of Five Million Dollars ($5,000,000.00) on behalf of REPUBLIC SERVICES, INC. and its subsidiaries, relating to the provision of solid waste collection, transportation, transfer, recycling, disposal and/or energy services by REPUBLIC SERVICES, INC. and its subsidiaries and affix its corporate seal to and deliver for and on behalf as surety thereon or otherwise, bonds of any of the following classes, to wit:

1. Surety bonds, bid bonds, performance bonds and payment bonds to the United States of America or agency thereof, including those required or permitted under the laws or regulations relating to Customs or Internal Revenue; license and permit bonds or other indemnity bonds under the laws, ordinances or regulations of any state, city, town, village, board, other body organization, public or private; bonds to transportation companies; lost instrument bonds; lease bonds; worker's compensation bonds; miscellaneous surety bonds; and bonds on behalf of notaries public, sheriffs, deputy sheriffs and similar public officials.

2. Surety bonds, bid bonds, performance bonds and payment bonds on behalf of REPUBLIC SERVICES, INC. and its subsidiaries in connection with bids, proposals or contracts.

REPUBLIC SERVICES, INC. hereby agrees to ratify and confirm whatsoever KIBBLE & PRENTICE HOLDING COMPANY dba USI INSURANCE SERVICES NORTHWEST shall lawfully do pursuant to this power of attorney, and until notice or revocation has been given by REPUBLIC SERVICES, INC., the acts of said attorney shall be binding on the undersigned.

IN WITNESS WHEREOF, this Power of Attorney has been signed this 24th day of May, 2023 on behalf of REPUBLIC SERVICES, INC. by its Assistant Secretary, Adrienne W. Wilhoit.

REPUBLIC SERVICES, INC.,
a Delaware corporation

Adrienne W. Wilhoit

STATE OF ARIZONA

COUNTY OF MARICOPA

Subscribed and sworn to before me this 24th day of May, 2023 by Kiara Gonzalez, Notary Public.

KIARA GONZALEZ
Notary Public - Arizona
Maricopa County
Commission # 598522
My Comm. Expires Feb 2, 2025

Notary Public

CERTIFICATE

I, the undersigned, John B. Nickerson, Assistant Secretary of Republic Services, Inc., a Delaware corporation, do hereby certify that the foregoing Power of Attorney is true, correct, remains in full force and effect, and has not been revoked.

IN WITNESS WHEREOF, this Certification has been signed this 16th day of October, 2023 on behalf of REPUBLIC SERVICES, INC. by its Assistant Secretary, John B. Nickerson.

John B. Nickerson

EVERGREEN NATIONAL INDEMNITY COMPANY

Independence, Ohio

POWER OF ATTORNEY

Bond No. 880377

KNOW ALL MEN BY THESE PRESENTS: That the Evergreen National Indemnity Company, a corporation in the State of Ohio does hereby nominate, constitute and appoint:

Debbie Lindstrom

its true and lawful Attorney(s)-In-Fact to make, execute, attest, seal and deliver for and on its behalf, as Surety, and as its act and deed, where required, any and all bonds, undertakings, recognizances and written obligations in the nature thereof, PROVIDED, however, that the obligation of the Company under this Power of Attorney shall not exceed TWENTY-FIVE MILLION AND 00/100 DOLLARS ($25,000,000.00)

This Power of Attorney is granted and is signed by facsimile pursuant to the following Resolution adopted by its Board of Directors on the 23rd day of July, 2004:

> "RESOLVED, That any two officers of the Company have the authority to make, execute and deliver a Power of Attorney constituting as Attorney(s)-in-fact such persons, firms, or corporations as may be selected from time to time.
> FURTHER RESOLVED, that the signatures of such officers and the Seal of the Company may be affixed to any such Power of Attorney or any certificate relating thereto by facsimile; and any such Power of Attorney or certificate bearing such facsimile signatures or facsimile seal shall be valid and binding upon the Company; and any such powers so executed and certified by facsimile signatures and facsimile seal shall be valid and binding upon the Company in the future with respect to any bond or undertaking to which it is attached."

IN WITNESS WHEREOF, the Evergreen National Indemnity Company has caused its corporate seal to be affixed hereunto, and these presents to be signed by its duly authorized officers this 1st day of April, 2022.

EVERGREEN NATIONAL INDEMNITY COMPANY

EVERGREEN NATIONAL INDEMNITY COMPANY CORPORATE SEAL 1939 OHIO

By: _____
Matthew T. Tucker, President

By: _____
David A. Canzone, CFO

Notary Public)
State of Ohio) SS:

On this 1st day of April, 2022, before the subscriber, a Notary for the State of Ohio, duly commissioned and qualified, personally came Matthew T. Tucker and David A. Canzone of the Evergreen National Indemnity Company, to me personally known to be the individuals and officers described herein, and who executed the preceding instrument and acknowledged the execution of the same and being by me duly sworn, deposed and said that they are the officers of said Company aforesaid, and that the seal affixed to the preceding instrument is the Corporate Seal of said Company, and the said Corporate Seal and signatures as officers were duly affixed and subscribed to the said instrument by the authority and direction of said Corporation, and that the resolution of said Company, referred to in the preceding instrument, is now in force.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed my official seal at Cleveland, Ohio, the day and year above written.

Julie K Bowers
Notary Public
in and For the State of Ohio
My Commission Expires
August 13, 2024

_____
Julie K. Bowers, Notary Public
My Commission Expires August 13, 2024

State of Ohio) SS:

I, the undersigned, Secretary of the Evergreen National Indemnity Company, a stock corporation of the State of Ohio, DO HEREBY CERTIFY that the foregoing Power of Attorney remains in full force and has not been revoked; and furthermore that the Resolution of the Board of Directors, set forth herein above, is now in force.

Signed and sealed in Independence, Ohio, this 16th day of October, 2023.

EVERGREEN NATIONAL INDEMNITY COMPANY CORPORATE SEAL 1939 OHIO

_____
Wan C. Collier, Secretary

UIC CLASS I INJECTION WELL PERMIT APPLICATION

COMMERCIAL NON-HAZARDOUS CLASS I INJECTION WELL, NORTH TEXAS INDUSTRIAL FACILITY, ITASCA HILL COUNTY, TEXAS

REPUBLIC INDUSTRIAL & ENERGY SOLUTIONS LLC

VOLUME I OF III - SECTIONS II THROUGH XII

PROJECT NO.: 192128M
DATE: JANUARY 2024

WSP
16200 PARK ROW, SUITE 200
HOUSTON, TX 77084

PHONE: 281-589-5900

WSP.COM

II. INFORMATION REQUIRED TO PROVIDE NOTICE

II.A SURFACE LANDOWNERS

A list of landowners and addresses for landowners of the facility property and of property adjacent to the facility is keyed to the figure in Attachment G.

II.B MINERAL OWNERS

A list of mineral owners and addresses for mineral owners beneath the facility and adjacent to the facility boundary is keyed to the figure in Attachment G.

II.C PERMANENT SCHOOL FUND LAND

If the facility is located adjacent to navigable territorial waters of the state, or the State of Texas is an adjacent landowner and/or owner of mineral rights underlying the facility or adjacent tracts, your application may affect lands dedicated to the permanent school fund. A determination whether lands dedicated to the permanent school fund will be affected by TCEQ formal action on the application will be made by the Texas General Land Office (TXGLO).

In order for the TXGLO to make a determination, the TCEQ will provide notice to the TXGLO regarding the application. Provide the following information for inclusion in the notice to the TXGLO:

1. state the location of the permanent school fund land, mineral rights, or waters of the state that may be affected; and

2. describe any foreseeable impact or effect of the proposed permitted action may have on permanent school fund land.

A formal action or ruling by the Commission on an application affecting permanent school fund land that is made without the notice required by 30 TAC §39.651(c)(3) is voidable by the School Land Board as to any permanent school fund lands affected by the action or ruling. [TWC §5.115(c) and (g)]

Not Applicable.

II.D MUNICIPALITY AND COUNTY INFORMATION

The proposed well will be located in a facility that is outside of the territorial limits or extraterritorial jurisdiction of a municipality. The name and address of the county judge and county health authority where the well will be located are provided below:

(a) POSITION	(b) NAME	(c) ADDRESS
Mayor	James Bouldin	136 North Hill Street Itasca, TX 76055 Phone: 254-687-2201
Hill County Judge	Justin W. Lewis	1 North Waco Street P. O. Box 457 Hillsboro, TX 76645 Phone: 254-582-4020 Fax: 254-582-4028
Hill County Health Authority Director	Sharon Melville, MD	2408 South 7th Street Temple, TX 76504 Phone: 254-778-6744

II.E BILINGUAL NOTICE CONFIRMATION

If it is determined that a bilingual notice is required, the applicant is responsible for ensuring that the publication in the alternate language is complete and accurate in that language. Electronic versions of the Spanish template examples are available from the TCEQ to help the applicant complete the publication in the alternative language.

Bilingual notice confirmation for this application:

1. Is the school district of the elementary or middle school nearest to the facility required by the Texas Education Code to have a bilingual program?

   ☒ Yes ☐ No

   If no, alternative language notice publication not required.

2. If yes to question 1, are students enrolled in a bilingual education program at either the elementary school or the middle school nearest to the facility?

   ☒ Yes ☐ No

   If yes to questions 1 and 2, alternative language publication is required.
   If no to question 2, then consider the next question.

3. If yes to question 1, are there students enrolled at either the elementary school or the middle school nearest to the facility who attend a bilingual education program at another location?

   ☐ Yes ☐ No

   If yes to questions 1 and 3, alternative language publication is required.

   If no to question 3, then consider the next question.

4. If yes to question 1, has the elementary school or the middle school nearest to the facility been granted an exception from the requirement to provide a bilingual education program, as available under 19 TAC §89.1207(a)?

   ☐ Yes ☐ No

   If yes to questions 1 and 4, alternative language publication is required.

   If no to question 4, alternative language notice publication not required.

5. Provide the alternative language for which the bilingual education program(s) is provided or for which an exception has been approved.

The bilingual notice publication will be required in Spanish.

III. RAILROAD COMMISSION LETTER

A copy of the letter accompanying the application submitted to the Railroad Commission of Texas (RRC) to verify that the disposal well and injection of waste into the subsurface stratum will not endanger or injure any known oil or gas resources is provided as Attachment H. This section will be updated following receipt of the response from the RRC.

IV. FINANCIAL ASSURANCE, LIABILITY, AND FINANCIAL CAPABILITY

Republic Industrial and Energy Solution, LLC (RIES) has drafted a performance bond to meet the financial assurance requirements. The draft performance bond is provided in Attachment I. RIES will submit an originally signed performance bond at least 60 days prior to commencement of drilling operations for new wells. The performance bond will be in effect before commencement of drilling operations.

SECTION V

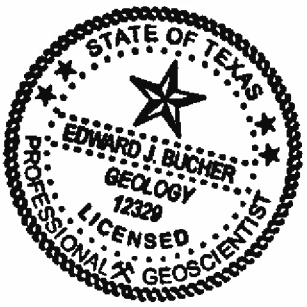
GEOLOGY AND HYDROGEOLOGY

GEOSCIENTIST'S SEAL

I, Edward J. Bucher, P.G., the undersigned, state: I am employed by WSP USA, and I am authorized to prepare this document. This document was prepared under my supervision and direction. The information in this document was prepared in accordance with generally accepted geosciences principles and practices.

This certification and seal apply to the following documents:

Pages V-1 through V-24
Tables V-1 through V-2
Figures V-1 through V-27



Name: Edward J. Bucher, P.G.
Title: Senior Geologist
WSP USA Inc.
Texas Geoscience Firm 50561

Signature Edward J. Bucher Date Signed 12/27/2023
Licensed Professional Geologist No. 12329

V. GEOLOGY AND HYDROLOGY

The information presented in this section demonstrates the geologic and hydrogeologic suitability of the North Texas Industrial Facility (NTI Facility) in Itasca, Texas for waste injection. RIES proposes to drill and operate one Class I Nonhazardous injection well, Injection Well No. 1 (IW-1), at the NTI Facility. A discussion of the regional geology and hydrogeology is presented in Section V.A. The local geologic and hydrogeologic setting in the vicinity of IW-1 is addressed in Section V.B.

V.A REGIONAL GEOLOGY AND HYDROGEOLOGY

The regional geologic area is defined as the concentrated vicinity around the NTI Facility in Hill County, Texas. The regional and structural geology, as well as the hydrogeology of North-Central Texas, is discussed in the following sections. The NTI Facility is located in the eastern part of the Fort Worth Basin (FWB). The generalized stratigraphic column showing the regional stratigraphy of the central/eastern portion of the FWB is provided as Figure V-1 (Magnani et al., 2017). Regional northeast-southwest and northwest-southeast structural cross-sections covering Tarrant County to Bosque County (cross section A-A') and from Parker County to the northeastern corner of Hill County are presented in Figure V-2 and V-3, respectively (Eastman and Murin, 2016).

V.A.1 REGIONAL STRATIGRAPHY

(a) PRECAMBRIAN PERIOD

The Precambrian core of the modern North American continent is referred to as the Laurentia or North American Craton (Dalziel, 1992). It is composed of granitic and metamorphic basement rocks and underlies most of what is now Central Texas. It is estimated between 570 million years and 1.4 billion years old (Pollastro et al., 2007).

Approximately 1.2 billion years ago, the Llano tectonic cycle, associated with the Grenville Orogeny of the eastern portion North American Craton, resulted in the folding and faulting of these Precambrian rocks (Hentz, 2020). The Precambrian basement rocks were exposed and eroded for more than 500 million years and can be seen presently, outcropping in the Llano Uplift area of Texas (Smye et al., 2019, Pollastro et al., 2007).

(b) CAMBRIAN PERIOD

During the Cambrian Period, various carbonates and sandstones were deposited including the Wilberns, Riley, and Hickory Formations (Pollastro et al., 2007). Approximately 750 million years ago, continental rifting formed a continental passive margin on the southern edge of North American Craton (Alsalem et al., 2018; Merrill et al., 2015). The development of the Atlantic (Iapetus) Ocean in this region (Alsalem et al., 2018; Smye et al., 2019), along with the subsided margin and advancement of shallow seas (Hentz, 2020), deposited siliciclastics, shelf facies, and deeper Ouachita basinal facies.

In research presented by Alsalem's et al., two samples were taken of sandstone beds in the Riley Formation in the southern region of the FWB. The sediments were composed of fluvial-shallow marine sandstone deposited in the shallow seas that covered the region (Alsalem et al., 2018). Although the extent of siliciclastic deposition during the Cambrian Period is unclear, they can be characterized as predominately quartz sand, with local feldspar present based on proximity to buried granite hills. The calcareous sandstones deposited during the Cambrian

grade laterally and vertically into the Hickory sandstone (Smye et al., 2019). The Hickory sandstone can be divided into three distinct units, the upper, middle, and lower Hickory sandstone. The lower unit is composed of coarse- to medium-grained, angular to subangular, poorly sorted quartzose sandstone, sourced from braided stream deposits, grading upward into tidal flat and intertidal estuarine deposits (Alsalem et al., 2018). The middle unit consists of fluvial-influenced, shallow subtidal estuarine and shoreface deposits (Alsalem et al., 2018). The upper unit is composed of coarse-grained, moderately to well-sorted, well rounded quartzose sandstone with iron-oxide ooids and cement, sourced from estuarine-shallow marine deposits (Alsalem et al., 2018). The upper Cambrian carbonates are generally more granular, glauconitic, and darker in color than those of the overlying Ellenburger and other Ordovician Formations (Smye et al., 2019). The Wilberns, Riley, and Hickory Formations are grouped and described as the Cambrian Formation on the regional cross-sections in Figures V-2 and V-3.

(c) ORDOVICIAN PERIOD

The deposition of carbonates, with small amounts of siliciclastic sediments (Merrill et al., 2015), continued due to the existing passive continental margin along the southern edge of the North American Craton. During the Ordovician Period, the Ellenburger Formation, Viola and Simpson Groups were deposited (Eastman and Murin, 2016; Montgomery et al., 2005). The Ellenburger Formation carbonates reflect the broad shallow seas that covered virtually all of Texas during the time of deposition (Pollastro et al., 2007). The Ellenburger Formation consists mainly of limestone and dolomite of varying grain size with small amounts of interbedded sandstone, conglomerate, and anhydrite of varying thickness (Merrill et al., 2015). For the purpose of this study, the Viola and Simpson Groups are combined and are referred to as Viola-Simpson Group.

The Ellenburger Formation is a complex carbonate system that possesses variable porosity and permeability due to the dominant diagenetic processes, such as dolomitization, karstification, and tectonic fracturing that have produced large cave systems, dolines, karst towers, solution-collapsed zones, and large tectonic fractures within the stratigraphic unit. Permeability in the Ellenburger Formation is mostly low due to the diagenetic alterations, however, the Ellenburger Formation is very heterogeneous and the permeability is highly variable. An average porosity and permeability within these lower Paleozoic units are from 5 to 14 percent, and 0.01 to 5,517 millidarcy (mD), respectively. Both porosity and permeability decrease with depth (Merrill et al., 2015). The general dip of the Ellenburger Formation is towards the southeast, as shown on the published regional cross-section B-B' (Figure V-3). The Ellenburger, Simpson, and Viola Formations are grouped and labeled as the Ellenburger Group on the regional cross-sections (Figures V-2 and V-3). A published regional structure map of the Ellenburger Formation is provided as Figure V-4 (Eastman and Murin, 2016).

An extreme drop in sea level at the end of the deposition of the Ellenburger Formation occurred, which resulted in prolonged platform exposure and extensive karst features identified in the upper part of the sequence (Montgomery et al., 2005; Pollastro et al., 2007). The Viola-Simpson Group was deposited over the composite unconformity that overlies the Ellenburger Formation during a marine transgression (Merrill et al., 2015).

The sediments of the Viola-Simpson Group consist of crystalline limestone and dolomitic limestone (Montgomery et al., 2005). The upper Viola-Simpson Group consists of mainly of carbonates, while the lower Viola-Simpson Group consists of carbonates and sandstones, often with significant amounts of shale (Eastman and Murin, 2016). The Viola-Simpson Group was periodically influenced by tectonic and eustatic events which produced regional unconformities, often identified by extensive paleokarst (Merrill et al., 2015). Much of the Viola-Simpson Group and the upper part of the Ellenburger Formation, were eroded throughout most of the

FWB, except for a wedge found in the northeast region between the Muenster Arch and the Ouachita Thrust Front.

(d) MISSISSIPPIAN, PENNSYLVANIAN, AND PERMIAN PERIOD

The southern edge of the North American Craton was a passive margin until at least the early Mississippian Period (Merrill et al., 2015). Any significant Late Ordovician, Silurian, Devonian, and Early Mississippian deposits were eroded; the greatest amount of erosion occurred towards the southwest (Smye et al., 2019).

In the middle Mississippian Period, the southern edge of the North American Craton underwent a collisional-subduction event creating the Marathon-Ouachita-Sonora orogenic system and initiated the development of the present-day structural features that define the FWB (Merrill et al., 2015). The thick marine sediments accumulated on the continental margins experienced folding, faulting, and partly metamorphism. This zone of deformation formed the Ouachita Structural Belt, which trends northeast between San Antonio and Dallas, and extends from east to west from San Antonio and Del Rio (Ward, 2006).

During the late Mississippian, the highly organic and radioactive Barnett Shale (Montgomery et al., 2005) was deposited mostly in Northeast-Central Texas, which reflects the proximity to the deepening trench and eroding Ouachita Thrust Front (Merrill et al., 2015). The Barnett Shale is especially thick to the northeast of the FWB, containing a significant amount of limestone, which rapidly decreases in thickness to the south and west of the FWB. This thickness distribution indicates that the limestone was likely deposited in a series of debris flows from a northern source. The Barnett Shale has low permeability, which forms a natural seal, effectively separating the Marble Falls and Ellenburger limestone aquifers from each other (Hornbach et al., 2016) (Appendix V-1).

Differential subsidence occurred throughout the region which allowed for the deposition of carbonates and marginal reef sediments on the uplifted shelf areas and predominantly siliciclastic sediments in basin depositional areas. During the Pennsylvanian Period, the Comyn Formation, Marble Falls Limestone, and Big Saline Formation were deposited along the western portion of the FWB region and the Smithwick Shale and Atoka Group clastics were deposited along the eastern portion of the FWB region (Merrill et al., 2015).

The Marble Falls Formation is generally composed of an upper limestone interval and a lower portion containing interbedded limestone and gray-black shale, often referred to as the Comyn Formation. The shale found in the lower limestone unit differs from the underlying, highly organic and radioactive, Barnett Shale (Montgomery et al., 2005). The Marble Falls grades from limestone at the Newark East Field into shale in the southern portion of the FWB. At the Newark East Field, this unit consists of dense, impermeable limestone that forms an effective barrier (Pollastro et al., 2007). Well data indicates that the Marble Falls Formation thins rapidly towards the southern portion of the basin, where the facies grades to shale (Pollastro et al., 2007).

Pennsylvanian strata deposited above the Marble Falls Formation consists of regressive clastic deposits, representing various prograding environments, and transgressive bank deposits. These terrigenous clastics were derived from the north and east, where uplift was associated with the Ouachita orogeny (Montgomery et al., 2005) and locally from the Muenster Arch to the north (Thompson, 1982).

Overlying the Marble Falls Formation is the lower Smithwick Shale which consists of dark colored mudstone (Grayson and Trite, 1988). The Hood Sandstone is deposited on the lower Smithwick Shale, it is composed of sandstone, conglomerate, and limestone. The Hood Sandstone is more common in the western part of Johnson County. The Big Saline Shale overlies the Hood Sandstone and consists of sandstone, conglomerate, and

limestone. The Hood Sandstone is grouped with the Big Saline Shale. The upper Smithwick Shale was deposited on the Big Saline and is a dominated by shale that appears to be sandy or silty in part (Eastman and Murin, 2016).

The Atoka Group overlies the upper Smithwick Shale. Atoka sandstone and shale includes the Grant sandstone and Bend conglomerate and may be up to 65% shale (Eastman and Murin, 2016). The Atoka Group generally consists of quartz-rich feldspathic (chert) sandstones. It contains 3 distinct packages of terrigenous sediments, listed from deepest to shallowest: (1) fluvially dominated fan-delta system deposits, (2) system of coalesced wave-dominated deltaic sediments, and (3) thin, poorly integrated, fluvially dominated fan-delta system sediments. Diagenetic events, mostly silica dissolution and cementation, are attributed to the net porosities of approximately 10 to 15 percent due to preservation of the original porosity between quartz overgrowths combined with the created secondary porosity by chert grain dissolution (Thompson, 1982). The Atoka, Grant Sandstone, and Bend Conglomerate are grouped together as the Atoka Group on the regional cross-sections (Figures V-2 and V-3).

Subsidence decreased in the FWB at the end of the Atoka Group deposition, as plate convergence ceased. The Ouachita Thrust Front however, continued to be a sediment supply source. The Ouachita Thrust Front was halted from its western migration when it reached the Concho platform, however, the continued overthrust of the Ouachita Thrust Front combined with the stalled western migration, shifted the basinal trough westward during the deposition of the Strawn Group (Merrill et al., 2015). The Strawn Group is divided into 2 stratigraphic divisions, listed from deepest to shallowest: (1) basin and submarine fan sediments, and (2) a progradational sequence of fluvial-deltaic and carbonate platform sediments (Trice, 1982).

By late Permian, the North American Craton was converging with adjacent cratons, and the supercontinent of Pangea was beginning to form. The convergence of the land masses ended deposition of open-marine sediments and allowed evaporate-rich sediments to accumulate across the region (Merrill et al., 2015). As the highly evaporate bodies appeared in the new hot, dry climate, deposits of salt, gypsum, and red muds accumulated (Hentz, 2020).

(e) TRIASSIC AND JURASSIC PERIOD

From the late Permian through the middle Jurassic Period (approximately 100 million years), what is now Central Texas was located on the continental margin of the North American Craton. Weathering and erosion wore down the Ouachita Structural Belt, which became a source for gravel, sand, and mud for the stream systems that were created. During the Triassic, the continental crust began to rift and created elongated basins, eventually leading to the creation of the Atlantic Ocean and Gulf of Mexico. The final configuration of the Gulf of Mexico was dictated by the location of the old Ouachita Structural Belt, due to the southeastern flank of the Ouachita Structural Belt subsiding relative to the belt of deformed rocks to the northwest (Ward, 2006).

This ancestral formation of the Gulf of Mexico occurred in the Late Jurassic (Ward, 2006), which consisted of continual continental extension and compressional cycles that are still occurring today (Hentz, 2020). Because of the constricted pathway, the ocean currents were forced to circulate into the ancestral Gulf of Mexico and the Atlantic Ocean. The climate became hot with high rates of evaporation, which produced extremely dense and saline waters. Salt precipitated along the margins of the basins, accumulating hundreds to thousands of feet thick, eventually being buried by younger sedimentary sediments (Ward, 2006). As the younger sedimentary beds were deposited over the salt layer, the salt became unstable and deformed by migrating up through the overlying sedimentary units into zones of lower pressure. Through this process, the salt created a variety of structures known as salt diapirs or domes, which are prominent subsurface features of this region. Significant oil and

natural gas traps occur in porous and permeable sandstones overlying and flanking the domes and the exceptionally thick salt provides storage for hydrocarbons, hydrogen, and other products in solution mined salt caverns (Hentz, 2020). As the Gulf of Mexico and the Atlantic Ocean continued to develop and become wider, the water slowly became less saline, approach more normal marine salinities and allowing for carbonate sediment deposition.

(f) CRETACEOUS PERIOD

After the assembly of Pangea and an erosional period, a thin layer of Cretaceous-age siliciclastic sediments was deposited (Merrill et al., 2015). Due to the pre-Cretaceous erosion, no Triassic or Jurassic sediments were preserved within the FWB (Pollastro et al., 2007) and the Cretaceous sediment, thickening towards the southeast, was deposited unconformably over the eastward dipping Paleozoic sediments (Magnani et al., 2017).

The northern shoreline of the Gulf of Mexico was in South-Central Texas in the early Cretaceous. Apart from the subaerial exposure of Precambrian and Paleozoic rocks in the Llano Uplift, the land was generally low-lying. Erosion from the Llano Uplift supplied sand and mud to the coastal-plain system throughout the region, which interfingered with layers of carbonate sediment deposited where the seas were shallow. The development of the Gulf of Mexico almost reached its present configuration, with the continental margin subsiding until the sea level almost overtook the Llano Uplift, even connecting to the Pacific Ocean in places, allowing thick deposition and accumulation of marine calcareous sediments (Ward, 2006).

Around 85 million years ago, several volcanoes erupted along the northern rim of the Gulf of Mexico, with some erupting enough lava to create volcanic islands consisting of dark, heavy, iron and magnesium rich volcanic rock. Evidence indicates that these eruptions were most likely caused from continued widening of the Gulf of Mexico in successive episodes. During this time, the Rocky Mountains began forming hundreds of miles to the northwest. Erosion occurred as the mountains were uplifted, while streams carried the sediment onto the marine shelf of Texas.

Lower Cretaceous sediments occur throughout the FWB and consist of the Glen Rose, Paluxy, and Goodland Formations in ascending order (Figure V-1). The Glen Rose Formation is characterized in South Texas as a single, discrete unit, consisting of argillaceous dolomite and anhydrite layers (Dennen and Hackley, 2012).

The Upper Cretaceous sediments are mostly thick layers of marl and calcareous clay, created from the mixing of the carbonate sediments and the influx of mud being carried from the uplifted Rocky Mountains (Ward, 2006). The Upper Cretaceous sediments of the FWB are comprised of the Eagle Ford Formation. The Eagle Ford Formation is most often classified as a hydrocarbon-producing shale formation. It also contains high carbonate content, as high as 70%, with interbedded sections of limestone, marls, shales and ash beds. The high carbon content, and subsequent lower clay content, makes it more brittle and frackable. The Eagle Ford Formation covers an area approximately 50 miles wide and 400 miles long in Texas. It varies in depth between 14,000 feet (ft) deep and 300 ft thick in the southeast and 4,000 ft deep and 50 ft thick towards the northwest (McMillan et al., 2016). The continental sea retreated towards the Gulf of Mexico Basin near the close of the Cretaceous period, approximately 65 million years ago (Ward, 2006). The Cretaceous Formations - the Eagle Ford, Goodland, Paluxy, and Glen Rose Formations - are shown grouped together on the regional cross-sections (Figures V-2 and V-3). The Cretaceous sediments dominate the surface geology in this region, as shown on the map in Figure V-5.

V.A.2 REGIONAL HYDROSTRATIGRAPHY

The principal aquifers of North-Central Texas are of Cretaceous age and consist of sand and limestone units. The Cretaceous System is composed of two series, Gulf and Comanche, each divided further into groups. The Gulf Series is divided into the following five groups from shallowest to deepest: Navarro, Taylor, Austin, Eagle Ford, and Woodbine (Klemt et al., 1975). The underlying Comanche Series is divided into the following three groups from shallowest to deepest: Washita, Fredericksburg, and Trinity (Klemt et al., 1975). Figure V-6 is a dip cross-section (northwest-southeast) approximately 7 miles south of the NTI Facility showing the hydrostratigraphy in the area. Regionally, the Trinity and the Woodbine aquifers are considered the major aquifers:

- The Woodbine sands consists predominantly of sand and shale, capable of yielding small to moderate amounts of water.
- The Trinity Group is divided into the Paluxy, Glen Rose, and Travis Peak Formations from shallowest to deepest, and collectively are referred to as the Antlers Formations.
    - The Paluxy consists of sand and shale capable of yielding small to moderate amounts of water.
    - The Glen Rose is predominantly a limestone and yields only small amounts of water.
    - The Travis Peak is composed of limestone, sand, and shale. It is the principal water bearing formation of Cretaceous age in the region and could yield large amounts of good quality water. The Travis Peak Formation is divided into the following seven members from shallowest to deepest: Hensell, Pearsall, Cow Creek, Hammett, Hosston, Sycamore, and Sligo.

(a) WOODBINE AQUIFER

The Woodbine Aquifer, the shallowest of the two major aquifers, consists of ferruginous, argillaceous sands, characterized by intense brownish discoloration in places, which are accompanied by bituminous laminated clays (Walcott, 1901). The Woodbine Formation trends in a north-south direction extending from the Red River to the north and to northern McClennan County to the south (Langley, 1999). The regional dip is to the east-southeast at an average rate of 33 ft per mile in the area west of the Ouachita Thrust Front in Hill County, increasing to 50 ft per mile in the vicinity of the fault zone and to 67 ft per mile near Hubbard in southeastern Hill County (Klemt et al., 1975). The Woodbine Group generally thickens to the northeast and thins to the south and southwest.

The Woodbine is used primarily as a source of water for rural domestic supply and livestock; however, several small towns and industries in Hill County obtain their supply from the Woodbine (Klemt et al., 1975). The Woodbine aquifer is divided into three water-bearing zones that differ considerably in productivity and quality. Only the lower two zones of the aquifer are developed to supply water for domestic and municipal uses (Ashworth and Hopkins, 1995). The water quality from the Woodbine aquifer ranges from fresh to slightly saline (less than 1,000 to 3,000 mg/l dissolved solids) in Hill County (George et al., 2011).

(b) TRINITY AQUIFER

The Trinity Aquifer extends through the central part of Texas from the Red River to the north and through the Hill Country to the south (Ashworth and Hopkins, 1995). The largest water level declines are in the Trinity Aquifer, occurring in counties along the IH-35 corridor in the Dallas–Fort Worth and Waco areas (George et al.,

2011). One hundred years ago, wells in much of the Trinity Aquifer flowed at the surface, releasing so much artesian pressure that most ceased to flow by the mid-1910s (George et al., 2011). The primary use is for municipalities, but it is also used for irrigation, livestock, and other domestic purposes.

The Trinity Group is comprised of several smaller Cretaceous age aquifers; they include the Paluxy, Glen Rose, Hensell, Twin Mountains, Travis Peak, and Hosston aquifers (Ashworth and Hopkins, 1995; Muller and Price, 1979). Updip, where the Glen Rose thins or is missing, the Paluxy and Twin Mountains coalesce to form the Antlers Formation (Klemt et al., 1975). These aquifers consist of limestones, sands, clays, gravels, and conglomerates. Their combined freshwater saturated thickness averages about 600 ft in North Texas and about 1,900 ft in Central Texas (George et al., 2011). Total dissolved solids (TDS) increase from less than 1,000 milligrams per liter in the east and southeast to between 1,000 and 5,000 milligrams per liter, or slightly to moderately saline, as the depth to the aquifer increase (George et al., 2011).

Forming the upper unit of the Trinity Group, the Paluxy Formation consists of up to 400 ft of predominantly fine-to-medium-grained sand interbedded with clay and calcareous shale (Klemt et al., 1975). The dip of the Paluxy is generally eastward with minor variations. The Paluxy is an important aquifer in the northern and central areas of the region and yields small to moderate amounts of water. The water quality from the Paluxy Aquifer ranges from fresh to slightly saline (less than 1,000 to 3,000 mg/l dissolved solids) in Hill County (George et al., 2011).

Underlying the Paluxy, the Glen Rose Formation forms a gulf-ward-thickening wedge of marine carbonates. The Glen Rose is composed primarily of limestone with some shale, sandy shale, clay, sandstone, and anhydrite (Klemt et al., 1975). From a featheredge near May in Brown County and northwest of Twin Mountains in Erath County, the Glen Rose gradually thickens southeastward and has a maximum thickness of 1,110 ft in Limestone County. The Glen Rose produces fresh to slightly saline water in localized areas on or adjacent to its outcrop, usually yields small amounts of water for domestic and livestock use. Away from the outcrop, water in the Glen Rose is highly mineralized and constitutes a potential source of freshwater degradation to wells completed in the underlying Travis Peak Formation (Klemt et al., 1975).

The basal unit of the Trinity Group consists of the Twin Mountains and Travis Peak Formations, which are laterally separated by facies change (Ashworth and Hopkins, 1995). To the north, the Twin Mountains Formation consists mainly of medium- to coarse-grained sands, silty clays, and conglomerates (Ashworth and Hopkins, 1995). The Twin Mountains is the most prolific of the Trinity aquifers in North-Central Texas; however, the quality of the water is generally not as good as that from the Paluxy or Antlers Formations (Klemt et al., 1975). To the south, the Travis Peak Formation contains calcareous sands and silts, conglomerates, and limestones (Ashworth and Hopkins, 1995).

The Travis Peak underlies the Glen Rose Formation throughout the region. In the subsurface, the Travis Peak extends throughout the region, east of its outcrop. The formation is subdivided into the following members in descending order: Hensell, Pearsall, Cow Creek, Hammett, Sligo, Hosston, and Sycamore. The Hensell and Hosston Members are the more prolific members of the Travis Peak Formation in the region. The Pearsall, Cow Creek, Hammet, Sligo, and Sycamore pinch out and are absent in the region (Figure V-6). The Travis Peak Formation in much of the region is composed of a lower sand unit, a middle argillaceous unit, and an upper sand unit (Klemet et al., 1975).

The Hensell Member underlies the Glen Rose Formation, and consists of sand and sandstone, occasionally conglomerate, shale and clay, and some limestone (Klemt et al., 1975). The approximate maximum thickness of the Hensell Member is 178 ft in Erath County, but generally decreases in thickness to the east and southeast. The

Hensell Member yields small to large amounts of water (Klemt et al., 1975). Most domestic and livestock wells drilled in the Travis Peak Formation are completed in the Hensell. The water quality from the Hensell Member ranges from fresh to slightly saline (less than 1,000 to 3,000 mg/l dissolved solids) in Hill County (George et al., 2011).

The Hosston Member is the deepest unit in the Travis Peak Formation in the region, and generally consists of sand, sandstone, conglomerate, shale, and clay (Klemt et al., 1975). The Hosston exists as a distinguishable unit in essentially the entire study region east of the outcrop. The Hosston is the most important aquifer in the region (Klemt et al., 1975). The Hosston Member has a regional dip to the east in the northern, central, and western parts of the region and to the southeast in the area adjacent to and east of the Balcones Fault Zone. Locally, the direction may vary due to the depositional structure and localized thickening or thinning of the Hosston (Klemt et al., 1975). The approximate maximum thickness of the Hosston Member is 1,555 ft in Milam County, but generally decreases in thickness to the west and northwest. The Hosston Member yields moderate to large amounts of water (Klemt et al., 1975). The water quality from the Hosston Member ranges from fresh to slightly saline (less than 1,000 to 3,000 milligrams per liter (mg/L) TDS) in Hill County (George et al., 2011).

The deepest base of the underground source of drinking water (USDW) in the Hill County area is the base of the Hosston Member. Around the NTI Facility, it has been identified at a depth of 2,500 ft BGL (1,770 ft below mean sea level (BMSL)) as a conservative measure. Electric logs from nearby wells indicate that all formation fluids encountered beneath the Hosston Member exceed 10,000 mg/L TDS. The underlying impermeable shale of the Upper Pennsylvanian Strawn Group serves to confine the movement of water beneath the base of the USDW.

V.A.3 CONFINING AND INJECTION ZONE

(a) CONFINING ZONES

The Confining Zone, or upper Confining Zone, is defined as the stratigraphic unit or units above the Injection Zone that will prevent the vertical migration of fluids from the Injection Zone. The Confining Zone in the Itasca region consists of the Mississippian Barnett Shale, which is primarily composed of organic-rich siliceous, calcareous, and noncalcareous mudstones (Abouelresh and Slatt, 2012). The Confining Zone in the area of the proposed injection well is estimated to extend vertically approximately 260 ft from about 8,260 ft to 8,520 ft BGL (7,540 to 7,800 ft BMSL). The Barnett Shale serves as a Confining Zone because these mudstones are thick, nonporous, and impermeable. The Confining Zone is laterally continuous across the region (Figure V-2 and V-3). The Barnett Shale Confining Zone will serve as a barrier for vertical fluid movement and prevent fluid migration into overlying strata. Although subsurface data is limited and several faults occur in the region, including a northeast-southwest trending fault with approximately 200 ft of vertical displacement located about 5,000 ft southeast of the proposed injection site, the data suggests that the upper Confining Zone is free of transmissive faults or fracture zones within the Area of Review (AOR) that could allow the migration of fluid into the freshwater aquifers of the area.

The formations of Cambrian age lying below the base of the Ellenburger Formation and above the Precambrian granitic basement rocks are defined as the lower Confining Zone. The stratigraphic column in Figure V-1 (Magnani et al, 2017) and the cross-sections in Figure V-2 and V-3 (Eastman and Murin, 2016) show or imply that the stratigraphic interval below the Ellenburger Formation is composed of Cambrian shelf limestones, dolomites, and sandstones of the Wilberns Formation and the underlying Riley Formation. However, at least locally, detailed

well log analysis (Smye et al, 2019) has identified a Cambrian granite wash or weathered granite formation occurring above the unaltered Precambrian basement and below the base of the Ellenburger Formation. In the Itasca area, as demonstrated in the EOG Resources Gordon SWD 1 well (API No. 42217304570000) located 9 miles southwest of the proposed injection site, the Cambrian limestones and dolomites seem to be absent (Smye et al, 2019).

The lower Confining Zone, as defined for the Itasca area, is the approximately 120-ft thick granite wash/weathered granite lying immediately above the Precambrian basement and below the Ellenburger Formation. The detail mineralogic and lithologic data from logs is described in greater detail in Section V.B. The Cambrian granite wash/weathered granite will serve as the Confining Zone beneath the Injection Zone because of its lack of porosity and permeability. The Precambrian basement granitic rocks lying below the Cambrian granite wash/weathered granite lower Confining Zone provide additional lower confinement for the Ellenburger Injection Zone. The regional lateral continuity of the lower Confining Zone is shown by the lateral distribution of Cambrian strata on the regional cross-sections in Figures V-2 and V-3).

(b) INJECTION ZONE

The potential Injection Zone defined for this Class I nonhazardous disposal well is the Ellenburger Formation of Cambrian to Ordovician age. Based on available data from the Railroad Commission of Texas (RTC), Texas Commission on Environmental Quality (TCEQ), and published documentation, the cross-sections in Figures V-2 and V-3 illustrate the excellent lateral continuity and thickness of the Ellenburger Formation in the region. The Injection Zone consists of interbedded dolomites, dolomitic limestones, and limestones which occur in the depth interval from approximately 8,500 ft to 12,300 ft BGL (7,800 ft to 11,600 ft BMSL) at the proposed injection well location and has a thickness of approximately 3,800 ft.

The Ellenburger Formation is an effective Injection Zone in terms of its petrophysical characteristics, mineralogical composition, and aerial extent. It has sufficient porosity, permeability, thickness, and lateral continuity to readily accept and contain injected fluids (Section V.B.3).

V.A.4 REGIONAL CROSS-SECTIONS

The structural cross-section B-B' (Figure V-3) represents the general regional stratigraphy and structure for Johnson and Hill Counties.

V.A.5 REGIONAL STRUCTURAL GEOLOGY

The FWB is the dominant regional structure in the greater NTIF area. The FWB is a shallow trough covering an area of approximately 15,000 square miles in Northeast-Central Texas (Figure V-7). It is one of several basins created during the late Paleozoic Ouachita orogeny, a major thrust-fold deformation (Montgomery et al., 2005) produced by the collision of the North American Craton, Laurentia, and the South American Craton, Gondwana, during the formation of Pangea (Merrill et al., 2015; Montgomery et al., 2005).

The FWB is a wedge-shaped, north-south elongated deepening depression bounded by the following structural features: the Ouachita Thrust Front to the east; Muenster and Red River arches to the north; the Llano Uplift and

Balcones Fault to the south; and the Bend Arch to the west (Smye et al., 2019). A regional map of the FWB and its associated structures is provided in Figure V-7. The axis of the FWB trends approximately parallel to the Ouachita Thrust Front (Montgomery et al., 2005; Pollastro et al., 2007). The basin is deepest near the Ouachita Thrust Front, shallowing westward towards the Bend Arch (Eastman and Murin, 2016). Preserved fill in the FWB contains a maximum of approximately 12,000 ft in the northeast corner of the basin, near the Muenster arch. The subsurface stratigraphic section includes approximately 4,000 – 5,000 ft of Ordovician-Mississippian carbonates and shales, and 6,000 – 7,000 ft of Pennsylvanian clastics and carbonates. In the eastern parts of the basin, Cretaceous sediments were deposited (Montgomery et al., 2005; Pollastro et al., 2007).

The Muenster Arch was the first structural element to form and served as a sediment source for the Atoka Group (Thomas, 2003). An additional sediment source was the Ouachita Structural Belt, with the Bend Arch confining the basin on the west. The formation of the Llano Uplift also impacted. The present dip of the basin (Thomas, 2003). Other structures in the FWB include major and minor faults, local folds, fractures, karst-related collapse, and thrust-fold structures (Montgomery et al., 2005; Pollastro et al., 2007).

(a) THE OUACHITA STRUCTURAL BELT

The Ouachita-Marathon-Sonora orogen is approximately 3,000 kilometers (1,864 miles) long and is composed of deformed Paleozoic rocks extending from Mississippi and Arkansas, southwestward through Texas, and westward through Chihuahua and Sonora (Poole et al., 2005). The Ouachita Thrust Front in Texas extends for approximately 900 miles and 850 miles of the 900 miles is buried beneath younger sedimentary rocks.

The northern limb of the belt extends from approximately the Ouachita Mountains of Oklahoma to Central Texas and is composed of three distinct zones: (1) a frontal zone of metamorphosed folded and thrust-faulted rocks consisting of Stanley shale and sandstone, (2) an intermediate zone of weakly metamorphosed dark clastic rocks, and (3) an eastern zone of highly sheared phyllites, slates, and metaquartzites. This eastern zone is interpreted as a thrust fault overlying the frontal and intermediate zones.

The western limb of the belt extends from approximately the Llano Uplift westward to the Marathon area, continuing into Mexico. The trend and configuration of the Ouachita Structural Belt was determined by the shape of the craton against which it was deformed (Flawn, 1959), appearing to “wrap around” the Llano Uplift (Rose, 2016). The Ouachita Thrust Front is the primary structure on the east side of the FWB with up to 12,000 ft of vertical offset (Montgomery et al., 2005; Turner, 1957). Faulting associated with the Ouachita Structural Belt is present in the eastern portion of the study area and in proximity to the AOR.

(b) THE LLANO UPLIFT

The Llano Uplift, a gentle structural dome approximately 75 miles in diameter, is situated in Central Texas (Mosher, Levine, & Carlson, 2008). This feature is located south of Hill County within multiple counties including Llano, Mason, McCulloch, San Saba, Lampasas, Gillespie, Burnet, and Blanco Counties (Rose, 2016). A product of the Grenville Orogeny (Mosher, Levine, & Carlson, 2008), the Llano Uplift is a large structural dome with Precambrian crystalline rocks surrounded by Paleozoic and Cretaceous sedimentary rocks. Structural contours over the Llano Uplift dip gently away in all directions from the center, the steepest dip being towards the northeast, east, southeast, south, and southwest, and the gentler dips beings towards the west, northwest, and north. The Llano Uplift is bounded by the Balcones Fault to the south and the Ouachita Thrust Front to the east (Rose, 2016).

The Balcones Fault Zone, which is greater than 20 miles wide, consists of a zone of normal faults composed of echelon strands mostly dipping to the southeast (Collins, 1994). The fault zone is thought to extend through Hill, Ellis, and Dallas counties, but the soil cover makes it difficult to trace (Reaser, 1961). Outcrop along the fault zone represents greater than 2,000 ft of Cretaceous shelf deposits, consisting of limestone, marl, and shale. Local areas within the zone are intensely fractured by small, connected faults and joints, partly influencing the karst features developed throughout this region (Collins, 1994).

(c) THE BEND ARCH

The Bend Arch applies to the broad, gentle, structural arch (Evanoff, 1976) that is Ordovician in age, covering approximately 63,000 square miles in North-Central Texas (Hornbach et al., 2016) (Appendix V-1), dipping northward from the Llano Uplift across West-Central Texas. The Bend Arch is a regional north-south trending anticline associated with the FWB on the east and the Permian Basin on the west. Due to the stability throughout part of geologic history, the environment allowed for deposition of reservoir beds beginning in the Ordovician through the Permian, leading to three significant lithologic differences that make the Bend Arch distinct from the Basins that Id on either side. The Caddo Formation, one of the more important oil and gas reservoirs, has a maximum thickness of almost 800 ft thick on the Bend Arch, while this formation thins to the west to approximately 100 ft, and grades abruptly into a series of clastic sediments to the east. A series of sands and conglomerates located beneath the Caddo Formation locally on the Bend Arch are also significant hydrocarbon producing sediments, especially in Eastland, Stephens, and southern Young Counties. Small Mississippian age limestone pinnacle reef mounds are located over the Bend Arch, accounting for numerous small oil and gas fields. These mounds are often several hundred feet thick and produce oil and gas in overlying strata due to the draping effect of these beds over the mounds (Evanoff, 1976).

V.A.6 REGIONAL SEISMICITY

A review of historical seismic activity through September 2023, within a 32.2-km (20-mile) radius of the NTI Facility proposed injection well, was obtained from the United States Geological Survey's (USGS, 2023) online National Earthquake Information Center (NEIC). Earthquakes, with epicenters within the area investigated, had known or estimated magnitudes up to 3 on the Richter Scale. A map of the epicenters, and the available data on each event, is presented on Figure V-8.

Seismic risk is very low in North-Central Texas, as is shown on the seismic hazard map of the United States (Figure V-9). Most of these earthquakes could be attributed to activity involving ancient basement features, i.e., the Llano Uplift, or major fault zones such as the Ouachita Thrust Front. The closest reported event occurred on June 12, 2011 (2.7 magnitude), with an epicenter located approximately 7 miles northeast of the site, near Italy, Texas (Figure V-8). The most recent event occurred on September 12, 2016 (2.6 magnitude) with an epicenter 2.5 miles northwest of Venus, Texas, approximately 19 miles north of the site (Figure V-8).

Faults occur throughout North-Central Texas, but geological conditions are not conducive to the production of significant seismic events related to fault activity. Fault movement and resulting earthquakes are caused by the buildup of stress and subsequent release of energy along faults (Holmes, 1976). The amount of stress that may accumulate along a fault is a function of the ultimate strength of the rock and the compressional forces across the fault plane (Billings, 1972). Warner and Lehr (1977) concluded that in order for fluid injection to trigger earthquakes, injection must increase fluid pressure on the fault plane to the point that frictional forces resisting

movement become less than the forces tending to cause movement. Regional fault studies indicate the basin has not experienced widespread or significant tectonic activity for approximately the past 300 million years (Muehlberger, 1965; Rozendal and Erskine, 1971; Huffman, 2003).

Small earthquakes have been quite common in North Texas since 2008, within a year or two after the inception of hydraulic fracturing which generates massive amounts of flowback fluid which is disposed using Class II injection wells (Frohlich et al., 2011). In the FWB since 2008, the cumulative number of earthquakes having magnitudes of 3 or more increases roughly exponentially, with discreet increases associated with individual earthquake sequences (Hornbach et al., 2016) (Appendix V-1). Increased fluid pressures within reservoirs related to injection may raise pore pressures sufficiently to lower friction and allow displacement along faults that have stored potential energy in the Injection Zones with a corresponding release of seismic energy.

Although, there is evidence for induced seismicity resulting from Class II injection wells in the FWB, a seismic assessment and Fault Slip Potential (FSP) analysis for the NTI Facility location has been performed (Appendix V-2). FSP analysis was modeled using a 5.64-mile radius area of interest around the proposed Class I location. Precambrian faults were identified from published material and were utilized in the evaluation of the FSP. Only one fault was identified within 5.64-mile radius study area of the NTI Facility during the FSP analysis. Based on the FSP analysis the proposed Class I location had a “very low” FSPs, meaning there is little to no risk of these wells inducing seismic activity.

V.A.7 REGIONAL GROUNDWATER FLOW IN THE INJECTION ZONE

The facility is located in the Prairielands Groundwater Conservation District (GCD). The GCD boundaries are coextensive with the boundaries of Ellis, Hill, Johnson, and Somervell Counties, Texas. The GCD covers an area of approximately 2,864 square miles. The GCD is located within the Brazos and Trinity River Basins. Regionally the runoff on the west side of the GCD flows primarily west to the Brazos River, and runoff on the east side of the GCD drains primarily to the east to the Trinity River. Topographically, the region is nearly level to gently rolling dissected plain (Hallmark, 1993); elevations range from about 400 to 900 ft above mean sea level (AMSL) (Walcott, 1901). The physiography of the region consists primarily of gently rolling prairieland, woodlands, and wooded bottomlands in the river valleys (Walcott, 1901).

The Ellenburger Formation crops out on the flanks of the Llano uplift in Central Texas and dips steeply away in all directions (Winslow and Kister, 1956). Water in the Ellenburger occurs in vugular, cavernous zones and in joints and fractures in the dolomite and limestone beds (Klemt et al., 1975). Due to this type of occurrence, the hydraulic properties are very unpredictable and extreme variations can occur in short distances. The quality of water deteriorates rapidly away from the outcrop, and at distances greater than 20 miles downdip it is generally unsuitable for domestic use (Klemt et al., 1975). In the study area, the water in the Ellenburger Formation is considered unusable due to its depth and high TDS content (Henry, 1982, Core Laboratories Inc, 1972). Furthermore, regionally the Ellenburger Formation is being used by several Class II saltwater disposal wells to inject flowback water from the fracking of the Barnet Shale (Pollastro et al., 2007, Hornbach et al., 2016, Smye et al., 2019) (Appendix V-1). The groundwater flow follows the dip of the Ellenburger Formation which is northward and eastward toward the Ouachita Structural Belt (Hornbach et al., 2016) (Appendix V-1).

V.B LOCAL GEOLOGY AND HYDROGEOLOGY

The NTI Facility is located near the town of Itasca in Hill County, Texas. The largest city in Hill County, Hillsboro, is approximately 8 miles south of Itasca, 55 miles south of Fort Worth, and 35 miles north of Waco. The NTI Facility and surrounding area is depicted on Figure V-10. Hill County covers 1,012 square miles of level plains and gently rolling hills within the Blackland Prairie, Grand Prairie, and Eastern Cross Timbers regions (Austin, 2020). The following sections discuss the local stratigraphy, structure, and hydrostratigraphy present within the AOR for the proposed injection well, IW-1. Local dip (north-south) and strike (west-east) structural cross-sections are included as Figures V-11 and V-12, respectively.

V.B.1 STRATIGRAPHY

Figure V-13 is a stratigraphic column showing the geologic units near the site. The north-south and west-east cross-sections (Figures V-11 and V-12) depict most of these formations. None of the wells within 9 miles of the proposed injection well site penetrates more than approximately 115 ft of the upper Ellenburger Formation immediately below the base of the Barnett Shale upper Confining Zone. The Cambrian granite wash/weathered granite and the Precambrian basement granitic rocks likewise have not been penetrated within nine miles of the proposed site. Therefore, most of the Ellenburger Formation stratigraphic interval and none of the granite wash/weathered granite and Precambrian basement granitic rocks can be shown on the cross-sections.

To acquire additional information on the formations below the base of the Barnett Shale, electric logs will be run to total depth in the proposed well and these formations will be picked on the logs. The formations that will be penetrated, in descending order are the Cretaceous sediments; Pennsylvanian Strawn Group, Atoka Group, upper Smithwick Shale, Big Saline Shale, lower Smithwick Shale; Mississippian Marble Falls Formation and Barnett Shale; Ordovician Ellenburger Formation; and the upper portion of the Cambrian granite wash/Precambrian weathered basement rocks.

There is no well log data or other definitive information that suggests that the Viola-Simpson Group carbonates are present within the region or within the AOR. A possible exception is the EOG Resources Gordon SWD 1 well (API No. 42217304570000), located approximately 9 miles southwest of the proposed well location, which possibly has 9 ft of Viola-Simpson Group carbonates within the depth interval of 8,646' – 8,655', which may represent a thin interval of basal Viola-Simpson Group carbonates and shales lying immediately below the base of the Barnett Shale. No other wells that penetrate formations below the base of the Barnett Shale, including those used in the cross sections in Figures V-11 and V-12, show clear evidence of the presence of Viola-Simpson carbonates in the greater Itasca area based on geophysical well log characteristics. The Viola-Simpson Group typically contains a significant number of shale units interbedded with carbonates, particularly in the Simpson, which are readily recognizable on gamma-ray logs.

(a) CRETACEOUS

Cretaceous sediments are found on the surface over all of Hill County (Figure V-5). These Cretaceous sediments consist of sandstone, shale, and limestone bed, which lie unconformably over Paleozoic age sediments (Eastman and Murin, 2016).

(b) PENNSYLVANIAN

The Pennsylvanian age clastic facies include the Strawn and Atoka Groups. Locally, the Strawn Group can be divided into three distinct units, in descending order, the upper shale, Strawn Sandstone, and the lower Strawn. The upper shale unit is a predominately shale with thin sandstone beds (Trice, 1982). The Strawn sandstone is predominately sandstone, with significant interbedded shale, generally thicker on the east side of the FWB near the proposed site. The lowest Strawn unit is a thin sporadic limestone unit (Trice, 1982). The Strawn Group is shown as one unit on the cross-section for the purpose of this permit.

Locally, the Atoka age sediments can be divided into four distinct units, in descending order: the Upper Atoka Shale, the Upper Atoka sands, the Middle Atoka Shale, and the Atoka Sandstone (Figure V-13). The Upper Atoka Shale is predominately shale with sparse, thin sandstone and limestone beds. The Upper Atoka sands unit is a thin unit which consists of sandstone with interbedded siltstone and shale and is found between the Upper Atoka sands and the Middle Atoka Shale. The Middle Atoka Shale underlies the Upper Atoka sands and is underlain by the Atoka Sandstone. The Atoka Sandstone is the lowermost unit of the Atoka and consists of sandstone and conglomerate with interbedded shale and siltstone beds. This unit is often used as a marker bed due to its presence everywhere within the FWB (Eastman and Murin, 2016). All the Atoka units have been grouped into one unit and labeled as Atoka Group for the purpose of this permit.

The Pennsylvanian stratigraphic units lying between the base of the Atoka Group and the top of the Mississippian Marble Falls Limestone can be subdivided into three distinct units, in descending order, as shown on the cross sections in Figures V-11 and V-12: the Upper Smithwick Shale, the Big Saline Shale, and the Lower Smithwick Shale. The Upper Smithwick Shale is predominantly a shale unit but locally contains sandstones and conglomerates of the Bend Conglomerate; the Big Saline Shale is composed of mostly of shale that is locally interbedded with limestone and sandstone; and the Lower Smithwick Shale which is predominantly shale with localized scattered thin beds of sandstone and/or limestone. The Grant Sandstone, which occurs in the upper portion of the Upper Smithwick, where present, is absent in the local study area. Another sandstone unit, the Hood Sandstone, is a thin unit consisting of sandstone, conglomerate, and limestone which is often stratigraphically similar to the Big Saline (Eastman and Murin, 2016) can be difficult to distinguish from the overlying Big Saline. For this reason, the Hood Sandstone, if present, has been grouped with the Big Saline Shale in the local study area. The Lower Smithwick Shale is a black spiculitic and fissile shale deposited under dysaerobic conditions (Grayson and Trite, 1988). For the purpose of this permit, the Smithwick Shale is divided into the Upper and Lower units which are separated by the Big Saline Shale.

(c) MISSISSIPPIAN

As discussed in Section V.A.3 (a), the Barnett Shale of Mississippian age is continuous across the study area and will serve as the Confining Zone for the proposed injection well. The Confining Zone is estimated to occur within the depth interval of approximately 8,260 ft to 8,520 ft BGL (7,540 to 7,800 ft BMSL) and is estimated to be approximately 260 ft thick at the NTI Facility. The lateral continuity and subtle lateral thickness changes of the Confining Zone are shown on the cross sections in Figures V-11 and V-12.

(d) ORDOVICIAN

The Ellenburger Formation is the Injection Zone for the proposed well. The Injection Zone is comprised of the entire Ellenburger Formation and is estimated to be from approximately 8,520 to 12,320 ft BGL (7,800 ft to 11,600 ft BMSL) and has a total estimated thickness of approximately 3,800 ft at the NTI Facility. The Ellenburger Formation is the oldest, deepest, and thickest karst dolomite/limestone formation, found throughout the entire FWB (Hornbach et al., 2016) (Appendix V-1).

The Ellenburger Formation forms a complex carbonate system that is characterized by variable porosity and permeability due to the dominant diagenetic processes that modified the formation after deposition, including dolomitization, karstification, and tectonic fracturing which have produced large cave systems (most of which are now collapsed), dolines, karst towers, solution-collapsed zones, and large tectonic fractures. Permeability in the Ellenburger Formation is may be locally low due to the extreme heterogeneity of the formation as a result of these diagenetic alterations. However, because the Ellenburger Formation is very heterogeneous, the formation porosity and permeability are quite variable, both laterally and vertically. The Ellenburger Formation is often considered a reservoir rock, having an average porosity and permeability from 5 to 14 percent, and 0.01 to 5,517 mD, respectively (Merrill et al., 2015). Geographically, the most significant injection occurs into the Ellenburger Formation in the central/eastern portion of the FWB. From 2006 to 2016, approximately 270 million cubic meters (1.7 billion barrels) of wastewater was injected into the Ellenburger Formation in the FWB (Hornbach et al., 2016) (Appendix V-1).

(e) CAMBRIAN

The Cambrian sedimentary units, from shallowest to deepest, include the Wilberns, Riley, and Hickory Formations. However, the lateral and vertical distributions of the Cambrian formations within the FWB are poorly understood due to the lack of deep well penetrations. For example, it is unclear as to whether or not the Hickory, the basal member of the Riley Formation, is present in the FWB or if it pinches out north of the Llano Uplift (Smye et al, 2019). The Hickory member of the Riley is described as being a sandstone composed of quartz grains and feldspar. The feldspar is locally important at the base of the Hickory member in proximity to the Precambrian granite basement (Smye et al, 2019). The limestones found in the Upper Cambrian are reported to be more granular, glauconitic, and darker in color than those of the overlying Ellenburger and the dolomites are finer grained (Smye et al, 2019), however, there is no apparent evidence that Upper Cambrian carbonates occur in the Itasca area of Hill County.

The detailed log analysis of the EOG Resources Gordon SWD 1 well (API No. 42217304570000) published by Smye et al (2019) seems to demonstrate that the Wilberns and Riley Formations, as described in several publications, are absent in the greater Itasca area of Hill County. Smye et al (2019) used an Ellenburger Model which distinguished between calcite, dolomite, quartz, clay, and porosity for the Ellenburger Formation carbonates and an Arkosic Model which distinguished between quartz, feldspar, clay, hematite, and porosity for all rocks penetrated by the well below the base of the Ellenburger Formation (Figure V-14). The results from the Ellenburger Model show that at least the lower Ellenburger is composed predominantly of dolomite with minor amounts of calcite, quartz, and clay and that there is no lithologic change indicating the presence of Cambrian carbonates below the Ellenburger Formation.

The Arkosic Model results indicate the presence of two distinct but, mineralogically similar, formations lying below the Ellenburger Formation in the Gordon SWD 1 well:

- 122 ft of formation occurring immediately below the Ellenburger Formation from 12,458 ft to 12,580 ft BGL, which is interpreted to be granite wash and/or weathered granite, composed of subequal amounts of quartz, feldspar, and clay plus a minor amount of hematite (an iron oxide mineral).
- Approximately 530 ft of feldspar-rich rock occurring from 12,580 ft to 13,110 ft (the well T.D.) containing lesser amounts of quartz and a minor amount of clay, which is interpreted to be relatively unaltered Precambrian basement granite.

The upper 122-ft interval, due to its high quartz and clay content, is more likely to be a granite wash, which is a feldspar-rich or arkosic sandstone derived from the local weathering and erosion of Precambrian granite basement rock, rather than a weathered granite. However, the distinction between granite wash and weathered granite cannot be made from well log data alone and is best made by acquiring cores of the formation. Regardless, the advanced log analysis data from the Gordon SWD 1 well indicates that the Wilberns and Riley Formation carbonates and sandstones, as they are usually characterized in the published literature, are absent in at least portions of Hill County, including the greater Itasca area.

In summary, the formations penetrated in the Gordon SWD 1 well below the base of the Ellenburger Formation from 12,458 ft to the TD of the well at 13,110 ft are characterized by rocks with significant quantities of feldspar, quartz, and clay. The upper 122 ft of this interval, occurring from 12,458 ft to 12,580 ft is probably an arkosic sandstone or granite wash. The 530 ft of rock penetrated from 12,580 ft to 13,110 ft is composed of relatively unaltered Precambrian basement granite. The correlative depths for the top of the granite wash and the top of the Precambrian basement granite are estimated to be approximately 12,330 ft (11,610 ft BMSL) and 12,450 ft (11,730 ft BMSL), respectively, at the proposed Itasca injection site. This approximately 120-ft thick interval is the lower Confining Zone for the Ellenburger Injection Zone.

V.B.2 HYDROSTRATIGRAPHY

Within the AOR, the Woodbine and Trinity Aquifers are the only formations that contain fresh and slightly saline waters (Figures V-6 and V-15). These aquifers contain waters with less than 10,000 mg/l TDS and meet the criteria for USDW. The lowermost unit in the Trinity Aquifer is considered to be the base of the Cretaceous and the base of the USDW.

The Woodbine Formation outcrops 12 miles west of the facility and dips east. It has a thickness of approximately 170 ft, and it can be found at a depth of approximately 500 ft AMSL (≈200 ft below ground level (BGL)) (Klemt et al., 1975). The water flow is generally in the downdip direction at approximately right angles to the strike of the beds. The flow direction is eastward with an average hydraulic gradient of 20 ft per mile, with only minor local variations. A small cone of depression at Hillsboro causes water to move into this area from all directions.

The Woodbine Aquifer is an important aquifer in Hill County where it contains fresh to slightly saline water and supplies water for domestic and livestock uses as well as to several small towns (Klemt et al., 1975). The Woodbine is composed of ferruginous, friable, fine-grained sand and sandstone that is locally indurated and also contains shale. Shale, clay, gypsum, and lignite increase vertically in the upper portion of the Woodbine. It contains generally good water quality but has high iron concentrations in some areas (Klemt et al., 1975).

Within the study area, the Woodbine Aquifer has a thickness around 170 ft, and it can be found at a depth of approximately 500 ft AMSL (≈200 ft BGL) (Klemt et al., 1975). The water flow is generally downdip at approximately right angles to the strike of the beds. The flow direction is eastward with an average hydraulic

gradient of 20 ft per mile, with only minor local variations. A small cone of depression at Hillsboro causes water to move into this area from all directions.

The Trinity Aquifer is the largest and most prolific aquifer within the AOR. It is comprised of several smaller aquifers, which include, from shallowest to deepest, the Paluxy, Glen Rose, and Travis Peak Formations (Ashworth and Hopkins, 1995; Muller and Price, 1979). The Paluxy Formation forms the upper unit of the Trinity Aquifer. It is composed predominantly of fine-grained, compact, friable, white quartz sand, and interbedded with sandy, silty, calcareous or waxy clay and shale. Within the AOR, the Paluxy Aquifer is around 100 ft thick and can be found at approximately 200 ft BMSL (≈900 ft BGL) (Klemt et al., 1975).

The Glen Rose Formation forms the middle unit in the Trinity Aquifer. It is composed predominantly of dense, finely crystalline, fossiliferous, and gray to tan in color marl and chalky limestone, some shale, and anhydrite. Around the study area, the Glen Rose Aquifer is around 600 ft thick and can be found at approximately 300 ft BMSL (1,000 ft BGL) (Klemt et al., 1975).

The Travis Peak Formation forms the lower unit of the Trinity Aquifer and includes the Hensell and Hosston Members within the study area. The Hensell Member is the upper sand unit of the Travis Peak Formation. The Hensell consists of fine- to coarse-grained sand and sandstone with much crossbedding; gravel or sandy conglomerate; usually poorly cemented, sandy to silty multicolored clays; and gray to green shales (Nordstorm, 1982). Around the study area, the Hensell Member is around 100 ft thick and can be found at approximately 900 ft BMSL (≈1,600 ft BGL) (Klemt et al., 1975).

The Hosston Member is the lower sand unit of the Travis Peak Formation. The Hosston is made up of medium- to coarse-sand, gravel, and sandy clay near the land surface, with small amounts of shale, sandstone, and conglomerate increasing with depth (Nordstorm, 1982). Within the AOR, the Hosston Member is around 160 ft thick and can be found at approximately 1,000 ft BMSL (≈1,700 ft BGL) (Klemt et al., 1975). The base of the USDW is considered to be at the base of the Hosston Member at approximately 1,200 ft BMSL (≈1,900 ft BGL), however a more conservative approach was adapted and the designated USDW is set at 1,550 ft BMSL (≈2,250 ft BGL).

V.B.3 DEFINITIONS

This section defines the base of the lowermost USDW, the Confining Zones, and the Injection Zone for the NTI Facility proposed Class I injection well. The geophysical log from EW Wright No. 1 (American Petroleum Institute (API) No. 42217000170000) was utilized to determine the approximate depth of the Lowermost USDW at the NTI Facility (Appendix V-3). Subsea depths to the tops of the confining zones and the injection zone, and their corresponding thicknesses from 2D seismic data (described in detail in Section V.B.5 and Appendix V-4) and the zone thicknesses from the geophysical well log from the Gordon SWD No. 001 (API No. 42217304570000, Appendix V-3) were used to estimate the depths of the upper and lower Confining Zones and the Injection Zone at the NTI Facility. The depths identified on the geophysical logs from the Gordon SWD 1 well and the projected depths for the proposed IW-1 well at the NTI Facility are listed in Tables V-1 and V-2 and shown in Figure V-16.

(a) LOWERMOST USDW

The Underground Injection Control (UIC) Program under Part C of the Safe Drinking Water Act in 40 CFR §144.3 defines USDW as an “aquifer or its portion” which:

1) Supplies any public water system; or

2) Contains a sufficient quantity of groundwater to supply a public water system; and

   a. currently supplies drinking water for human consumption; or

   b. contains fewer than 10,000 milligrams per liter (10,000 ppm) TDS.

The nearest geophysical log that recorded the lowermost USDW is from EW Wright No. 1 (API No. 4221700017), located approximately 3.4 miles from the NTI Facility (Appendix V-3). Based on the above referenced definition, the depth of the lowermost USDW was selected from this log, and then projected to the analogous depths at the NTI Facility based on the approximate dip of the formations. The depth of the lowermost USDW beneath the NTI Facility was identified at approximately 1,300 ft BMSL (2,030 ft BGL) (Table V-1). The depth will be confirmed after logging the open hole section comprising the surface casing interval for the proposed injection well. The surface casing will be set at least 100 ft below the confirmed lowermost USDW at the NTI Facility.

The North-South () and West-East (Figure V-12) Cross-Sections transecting the study area illustrate the vertical and lateral extent of the lowermost USDW. The cross-sections also show that the base of the USDW is separated from the top of the proposed Confining Zone and from the top of the proposed Injection Zone by approximately 6,200 ft and 6,500 ft of sediments, respectively.

(b) CONFINING ZONES

Upper Confining Zone

The Barnett Shale will serve as the upper Confining Zone for the proposed injection well. This unit is composed primarily organic-rich siliceous, calcareous, and noncalcareous mudstones. These nonporous and impermeable mudstones will provide a seal that will prevent the upward migration of the injected waste.

The Barnett Shale in the FWB is an unconventional gas reservoir that is targeted by horizontal drilling and is completed using multiple hydraulic fracturing stimulations. However, only one horizontal Barnett Shale well has been drilled within the 2.5-mile AOR and, since it was a dry hole, records show that the well was never hydraulically fractured. The nearest hydraulically fractured Barnett Shale producing wells are located approximately 2.9 miles East, 3.4 miles NW, 3.5 miles SW, and 4.1 miles NE of the NTI Facility. Most of the Barnett Shale horizontal gas wells are located 4 to 12 miles west, northwest, and southwest of the NTI Facility in northeastern Hill County and adjacent southeastern Johnson County. Barnett Shale wells are rare to the east in adjacent Ellis County (nearly 5 miles away) and none are present south of the NTI Facility in Hill County.

The estimated top of the upper confining zone for the proposed injection well is 8,260 ft GL. The estimated base of the upper confining zone is 8,520 ft GL. The estimated thickness of the upper confining zone is 260 ft. The upper confining zone and the confining units within the gross injection zone interval lying between the base of the upper confining zone and the top of the lower confining zone are sufficiently impermeable, thick, and laterally extensive to protect all strata above the injection intervals from contamination by the injected wastewater.

Lower Confining Strata

The lower Confining Zone strata for the Ellenburger Injection Zone is identified as Cambrian Granite Wash or arkosic sandstone which is stratigraphically defined as the strata occurring between the base of the Ellenburger and the top of the underlying Precambrian basement. It is not possible to distinguish between granite wash and weathered granite from well logs, however, the higher amounts of quartz and clay and the presence of hematite

in the lower Confining Zone (Smye et al, 2019) indicate that it is probably a granite wash or arkosic sandstone and not weathered granite. The proposed injection well has been designed to not penetrate the entire lower Confining Zone, which is expected to have a thickness of approximately 120 ft at the NTI Facility site.

These dense, nonporous and low permeability sediments will provide sufficient confinement of the injectate for the proposed Injection Zone and separate the Ellenburger Formation Injection Zone from the Precambrian basement rock. The average porosity of the Lower Confining Zone granite wash in the Gordon SWD 1 well, using density porosity calculated for a sandstone matrix, is 0%. The underlying Precambrian basement granitic rocks provide additional confinement below the granite wash.

(c) INJECTION ZONE

The Injection Zone is defined as the complex carbonate system comprising the entire Ellenburger Formation and is composed of interbedded dolomites, dolomitic limestones, and limestones. The Injection Zone contains reservoir rock with sufficient porosity, permeability, and net thickness to allow for the injection and storage of disposed fluids and is isolate from formations above and below by effective upper and lower confining zones.

The top of the Ellenburger Injection Zone occurs at an estimated depth of 8,520 ft BGL at the NTI Facility. The average gross thickness of the injection zone is approximately 3,800 ft.

The Ellenburger Formation porosity ranges between 2% and 12% but averages only 4% over the thickness of the entire formation (Manger, 1963). Despite the overall low porosity, the thick net reservoir in the Ellenburger injection interval in the upper half of the formation has an average porosity of 7% and is often in the 6% to 8% or greater range as determined from the density log from the EOG Resources Gordon SWD 1 well (API No. 42217304570000) located approximately 9 miles southwest of the proposed injection site. Due to the presence of connected vugs and other smaller pore types and generally small open vertical to subvertical natural fractures, the permeability of the Ellenburger in the injection zone is often fair to good. Regional studies combined with pressure fall-off tests indicate the formation has moderate permeability in the 0.1–500 mD range (Hornbach et al., 2016) (Appendix V-1).

(d) INJECTION INTERVAL

The Injection Interval for the proposed injection well is defined to be the same as the Injection Zone: the interval from the top to the base of the Ellenburger Formation. The Injection Interval contains the same lithologic and rock properties as the Ellenburger Formation described in Section V.B.3(c). These intervals are shown in Figure V-16 in Table V-2.

(e) CONFINING STRATA BENEATH THE INJECTION ZONE

The low porosities and permeabilities of the underlying Cambrian granite wash and Precambrian basement rocks provide excellent confinement below the Ellenburger Formation Injection Zone.

(f) UNINTERPRETED BASE MAP

An uninterpreted base map is included as Figure V-17.

V.B.4 LOCAL STRUCTURAL CROSS-SECTIONS

Dip and strike structural cross-sections transecting the AOR are presented as Figures V-11 and V-12, respectively.

V.B.5 LOCAL STRUCTURAL GEOLOGY

Due to the lack of wells penetrating the Ellenburger Formation and Precambrian basement, existing 2D seismic data was used to map the subsurface structure of the Barnett Shale, Ellenburger Formation, and Precambrian basement in order to gain a better understanding of the depths to the tops of the upper Confining Zone, Injection Zone, and lower Confining Zone and to aid in designing the proposed injection well. The data contained in four 2D seismic lines that transect the AOR was interpreted by Hill Geophysical Consulting (Hill, 2023; Appendix V-4). The seismic lines were acquired at different times by different companies using different acquisition and processing parameters. The 2D seismic data was reprocessed for the new evaluation and interpretation work and consists of two west-east lines, one northeast-southwest line, and one northwest-southeast line (Figure V-18).

The seismic data was converted to depth using a sonic log from the DTE Gas Resources Inc. Hooks P 690 7V well (API No. 42217304310000) which was used to generate a synthetic seismogram to tie the seismic reflections to the formation depths in the Hooks well. It was found that there is less than 50 ft of variation between the formation tops in the well and the seismic reflections when the Marble Falls and Ellenburger time values are converted to depth using the synthetic seismogram (Hill, 2023).

The following horizons were picked and interpreted from the 2D seismic profiles of each of the 2D lines presented in Figures V-19 through V-22:

- An unconformity lying approximately 3,000 ft BGL
- Marble Falls Formation
- Barnett Shale (upper confining zone)
- Ellenburger Formation (injection zone)
- Granite wash and Precambrian basement (lower confining zone)

Key seismic structure maps were constructed from the data for the tops of the Barnett Shale, Ellenburger Formation, and Precambrian basement which comprise the tops of the upper confining, injection, and lower confining zones, respectively. The seismic structure maps are provided in Figures V-23 through V-25.

The main observations and conclusions derived from the seismic work provided by Hill (2023) are:

- The 2D seismic data provides the only depth control for the deeper formations in the vicinity of the AOR since there is no well control within the 2.5-mile radius AOR of the proposed injection well site.
- Very little well control is present between 2.5 miles and 5 miles from the proposed site, and no wells within 9 miles of the proposed site penetrate the entire Ellenburger Formation Injection Zone.
- Only 25 wells in the seismic study area have penetrated the top of the Ellenburger Formation and none of the wells, except for the Gordon SWD 1 well located 9 miles SW of the proposed injection well site,

were drilled deep enough to penetrate the entire Ellenburger Formation, the Cambrian granite wash, and the Precambrian basement granite.

- The 2D seismic data, integrated with well log data where available, shows structural closure at the top of the Ellenburger Formation at the proposed injection well site and a structural nose plunging to the southeast across the AOR.
- On the southeast side of the AOR, approximately 5,000 ft from the proposed injection well site, the deep formations are cut by a 200 ft +/- down-to-the-east, northeast-southwest trending fault identified from the 2D seismic data.
- The 200-ft fault, the only fault within the 2.5-mile radius AOR, juxtaposes up-thrown Ellenburger on the NW side of the fault against Barnett Shale and uppermost nonporous Ellenburger Formation carbonates on the SE side of the fault.
- Since the fault terminates upward at an unconformity at a depth of approximately 3,000 ft BGL, it does not cross the base of the USDW and poses no threat of contamination to the USDW due to vertical migration of injected fluids along the fault plane.

V.B.6 FAULTS WITHIN THE AREA OF REVIEW

The Ouachita Structural Belt or Thrust Front (Figure V-7) is a massive, nearly impermeable geological boundary, with a strike that extends along a southwest-northeast trend (Budnik et al., 1990; Ewing, 1991). This major fault zone is located approximately four miles southeast of the proposed injection site and lies outside of the 2.5-mile radius AOR. Therefore, it will not compromise the integrity of the proposed Ellenburger Formation Injection Zone or the Barnett Shale Confining Zone.

A smaller southwest-northeast trending fault, which is located within the AOR approximately 5,000 ft from the proposed injection site, was identified during interpretation of the 2D seismic lines that transect the AOR (Hill, 2023) and is shown as a subvertical red line on the seismic profiles in Figures V-19 through V-22 and as a heavy red northeast-southwest oriented line on the structure maps in Figures V-23 through V-25 as well as on the seismic profiles and maps in Appendix V-4 (Hill, 2023). This fault has a vertical displacement of approximately 200 ft with the formations on the southeastern side of the fault having been moved downward relative to those on the northwest side of the fault. The vertical displacement along the fault juxtaposed the upthrown Ellenburger Formation in the northwest fault block against downthrown Barnett Shale in the southeast fault block. Although this fault occurs within the AOR, it does not compromise the integrity of the Ellenburger injection zone nor the overlying Barnett Shale upper confining zone since the vertical displacement was not great enough to juxtapose the Ellenburger injection zone up against shallower porous and permeable intervals above the Ellenburger Injection Zone. In addition, the seismic data shows that this fault terminates against an unconformity at a depth of about 3,000 ft BGL (Figure V-19 through V-21, Appendix V-4) and therefore does not extend upward into the protected USDW which occurs at a depth of approximately 2,000 ft BGL.

A second fault identified from the seismic data is located outside the AOR between the 200-ft fault and the Ouachita Structural Belt and is show as a heavy yellow line on the maps in Appendix V-4. The fault is similar in size and orientation to the fault identified within the AOR, however, since it is located approximately 3.6 miles

(19,000 ft) southeast of the proposed injection site and 2.7 miles (14,000 ft) beyond the fault within the AOR, it will have no impact on injection at the proposed site. This fault lies in close proximity to the leading edge of the Ouachita Structural Belt (Figure V-7).

V.B.7 CONFINING ZONE – LATERALLY CONTINUOUS

As discussed in Section V.A.3, the Confining Zone is comprised of primarily organic-rich, nonporous and impermeable, siliceous, calcareous, and noncalcareous mudstones of the Mississippian Barnett Shale. The Barnett Shale is laterally continuous throughout the region and in the vicinity of the site, as shown on the cross-sections in Figures V-11 and V-12 and the 2D seismic profiles in Figures V-19 through V-22. The Confining Zone mudstones or shales are sufficiently impermeable, thick, and laterally extensive to protect all strata above the Injection Zone from contamination by injected wastes.

V.B.8 CONFINING ZONE - THICKNESS AND LITHOLOGY

In the vicinity of the NTI Facility, the Confining Zone, which is defined as the Barnett Shale, has an estimated thickness of approximately 260 ft and is comprised of mostly of nonporous and impermeable, organic-rich, siliceous, calcareous, and noncalcareous mudstones. The thickness, as well as the continuity, of the Confining Zone throughout the AOR and beyond is shown on the well log cross sections in Figures V-11 and V-12 and is demonstrated by the isopach map of Confining Zone from seismic data in Figure V-26.

V.B.9 DEMONSTRATION

Confining Zone (Separation of USDW by Impermeable and Permeable Beds)

The North-South and West-East cross-sections in Figures V-11 and V-12, respectively, illustrate the stratigraphy of the interval between the base of the USDW and the top of the Confining Zone. The base of the USDW is separated from the top of the proposed Injection Zone by approximately 6,500 ft of sediments. The sediments consist of locally common sands interbedded with more common low-permeability limestones, shales, and clays. The net thickness of impermeable strata in the stratigraphic interval between the top of the Injection Zone and the base of the USDW, most of which is comprised of shale, will provide added protection for the USDW in the event of fluid movement in an unlocated abandoned borehole.

Injection Zone – Thickness and Lithology

The Injection Zone, which is defined as the thickness of the entire Ellenburger Formation, ranges in thickness up to approximately 4,000 ft and is estimated to be 3,800 ft thick at the NTI Facility. The isopach map of the Injection Zone, constructed from the subsea depth differences between the top of the Ellenburger and the top of Precambrian seismic structure maps is presented in Figure V-27 (Hill, 2023).

V.B.10 SEISMICITY ASSESSMENT

(a) RECORDED SEISMICITY

The seismic activity of the area is discussed in Section V.A.6.

This assessment indicates that there is no potential for injection into the proposed well to result in a seismic event. This is supported by the fact that the volume of wastewater to be injected into the proposed Class I well will not be significant enough to induce seismic activity.

(b) INJECTION WITHIN THE AOR

There are no wells that inject fluids in the Ellenburger Formation within the AOR.

(c) PATTERN OF INJECTION

Since there are no injection wells within the AOR, there is no pattern of injection within the Ellenburger Formation to report within the proposed area.

(d) THICKNESS OF SEDIMENTS BETWEEN THE BASE OF THE INJECTION ZONE AND THE BASEMENT

The confining strata underlying the Injection Zone is comprised of granite wash or arkosic sandstone of Cambrian age lying immediately below the base of the Ellenburger Injection Zone and above the top of the unaltered Precambrian basement.

The structure of the top of the Cambrian granite wash is not mappable since there is only one well within the regional study area that penetrates it: the EOG Resources Gordon SWD 1 well (API No. 42217304570000), which is 9 miles southwest of the proposed IW-1 site. The top of the Cambrian granite wash in the Gordon well is at 12,430 ft BGL. In the Gordon SWD 1 well, 680 ft of Cambrian granite plus underlying Precambrian granitic basement rock was penetrated and the well reached a total depth of 13,110 ft. The Gordon SWD 1 well penetrated 122 ft of granite wash, some of which may be weathered Precambrian basement, and 558 ft of Precambrian basement granite. At the proposed injection well, the top of the granite wash/base of the Injection Zone is estimated to occur at 12,320 ft BGL. This depth corresponds to the top of the Precambrian basement for the seismic data since the granite wash interval is too thin and too similar to the Precambrian granite to be discerned on seismic sections.

(e) CHARACTERISTICS OF LOWER CONFINING STRATA

Characteristics of the Cambrian granite wash that comprises the lower confining strata are discussed in Section V.B.3(b).

(f) FAULTS WITHIN THE AOR

Seismic data interpretation of four 2D seismic lines (Figures V-19 through V-22, Appendix V-4) that transect the AOR shows the presence of a northeast-southwest trending fault exhibiting approximately 200 ft of vertical displacement within the AOR. This fault is located approximately 5,000 ft southeast of the proposed injection well location. The character of this fault is discussed in greater detail in Section V.B.6.

The fault terminates vertically at a regional unconformity at a depth of approximately 3,000 ft BGL and therefore does not come in contact with or threaten the shallower USDW (Figures V-19 through V-21). Also, the fault juxtaposes Barnett Shale Confining Zone against nonporous and impermeable upper Ellenburger carbonates, which will prevent leakage of injected fluids across the fault.

It is not likely to be a pathway for injected fluids to migrate from the injection zone downward into the Precambrian basement rock since the 200 ft of vertical displacement along the fault has juxtaposed nonporous and impermeable lower Confining Zone granite wash in the northwest fault block against the basal portion of the Ellenburger where porosity and permeability are also not well developed.

V.B.11 SURFACE GEOLOGY

The NTI Facility is located within the outcrop of the Eagle Ford Shale Formation (Late Cretaceous) which covers approximately a quarter of Hill County (Figure V-5). The outcropping Eagle Ford Shale Formation consists essentially of a bituminous clay, accompanied in places by thin laminated limestones. On the east side of the facility, the Austin Chalk Formation (Late Cretaceous) outcrops, covering 14% of Hill County, are composed of fine-grained chalk and marl deposited in a deep-water marine-shelf environment (Hovorka and Nance, 1994).

V.C AREA WELL LOGS

Logs of wells used to construct the cross-sections (Figures V-11 and V-12), and the log from the EOG Resources Gordon SWD 1 key deep well, are included in Appendix V-3.

TABLES

Table V-1

Estimated Depth of USDW, Confining Zones, and Injection Zone at Republic's Itasca Landfill

	Depth (ft. MSL)	Depth (ft. BGL)
USDW	1,300	2,030
Upper Confining Zone	7,540	8,260
Injection Zone	7,800	8,520
Lower Confining Zone	11,600	12,320

Table V-2

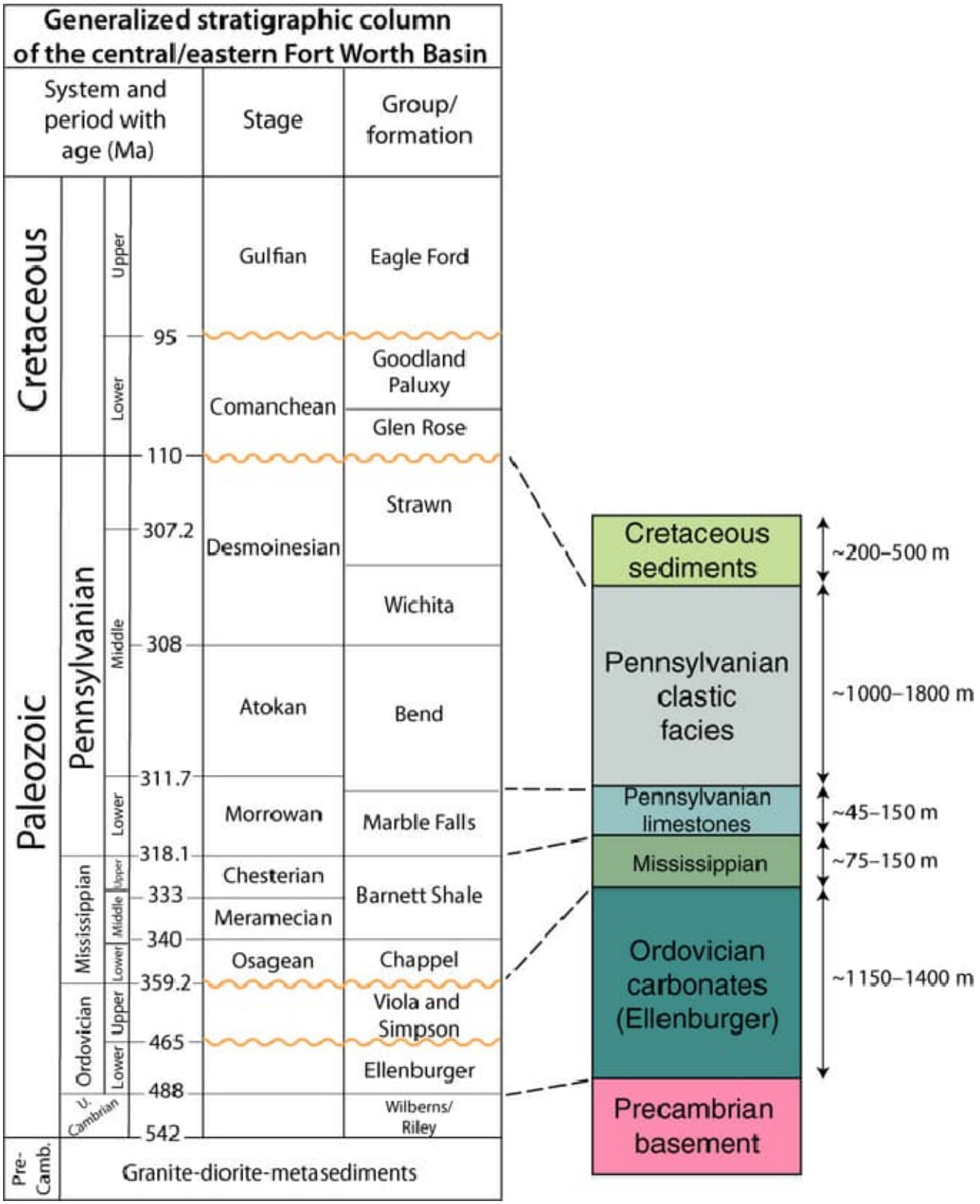
Estimated Thickness of the Injection Interval Beneath the Itasca Landfill

	Top Depth (ft. BGL)	Base Depth (ft. BGL)	Gross Thickness (ft.)	Estimated Net Thickness (ft.)
Injection Interval at SWD Gordon No.1	8,645	12,458	3,813	196[1]
Itasca Facility Estimated Thickness based on Seismic Data	8,520	12,320	3,800	150[2]

[1] Net Thickness Estimated based on Gordon SWD No.1 (API 4221730457) Log Porosity > 6% (Figure V-16).

[2] Conservative estimate of thickness at the Itasca Facility based Net Thickness from offset Gordon No. 1 SWD well approximately 9 miles from Itasca Facility.

FIGURES



Source: Magnani, M. B., Blanpied, M. L., DeShon, H. R., and Hornbach, M. J., 2017

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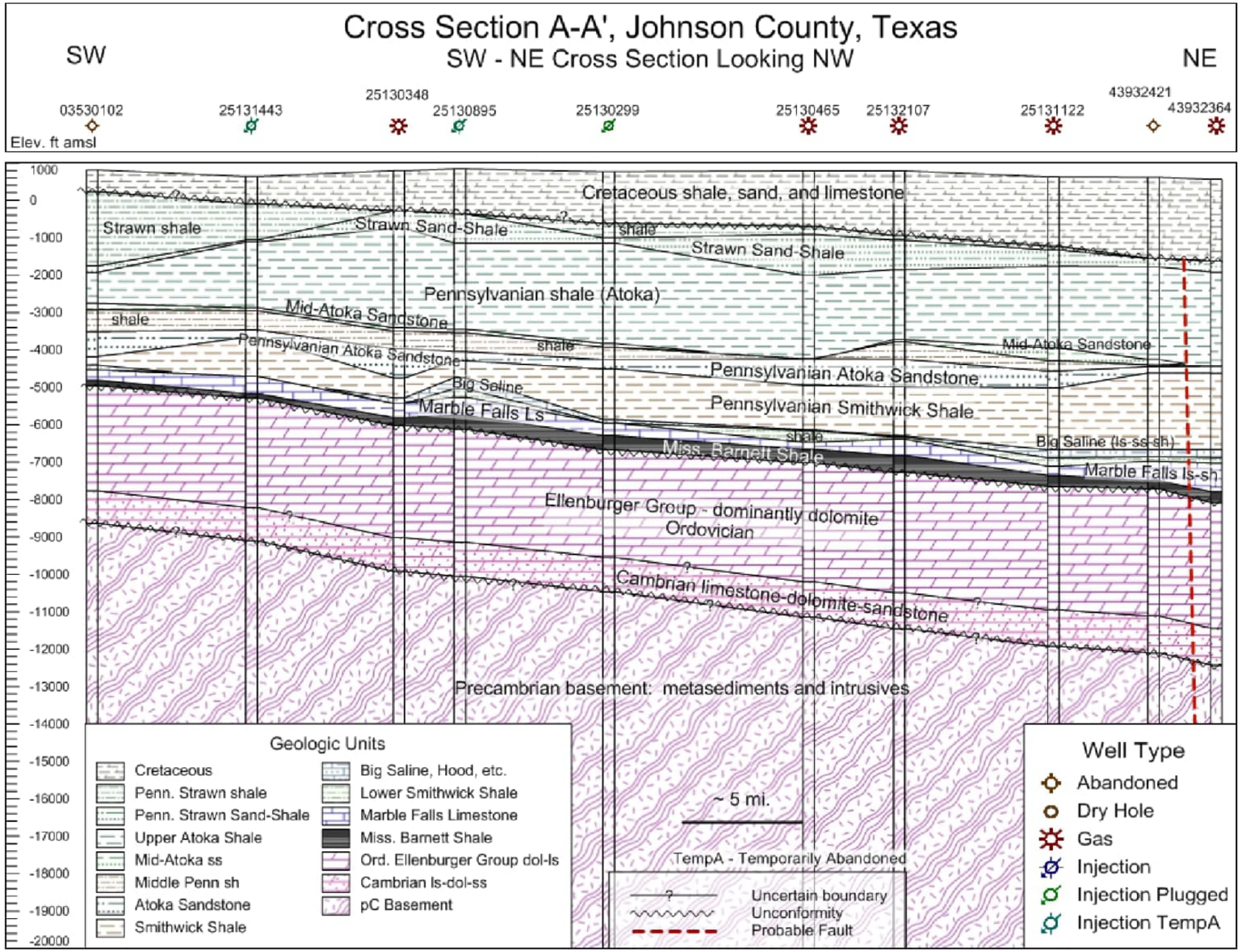
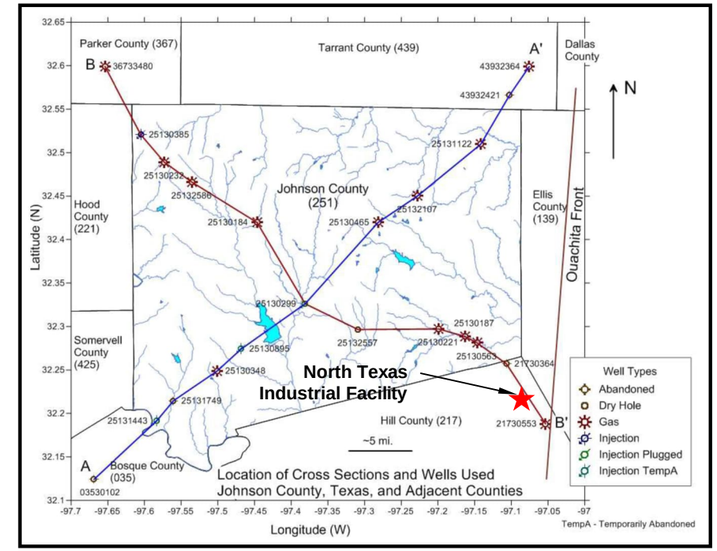
GENERALIZED STRATIGRAPHIC COLUMN OF THE CENTRAL/EASTERN FORT WORTH BASIN

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 10/19/2023	Scale: NONE	Figure No. V–1





Source: Figure 5, Geologic Characterization of Johnson County, Texas, NETL, Office of Fossil Energy, December 14, 2016, p. 26

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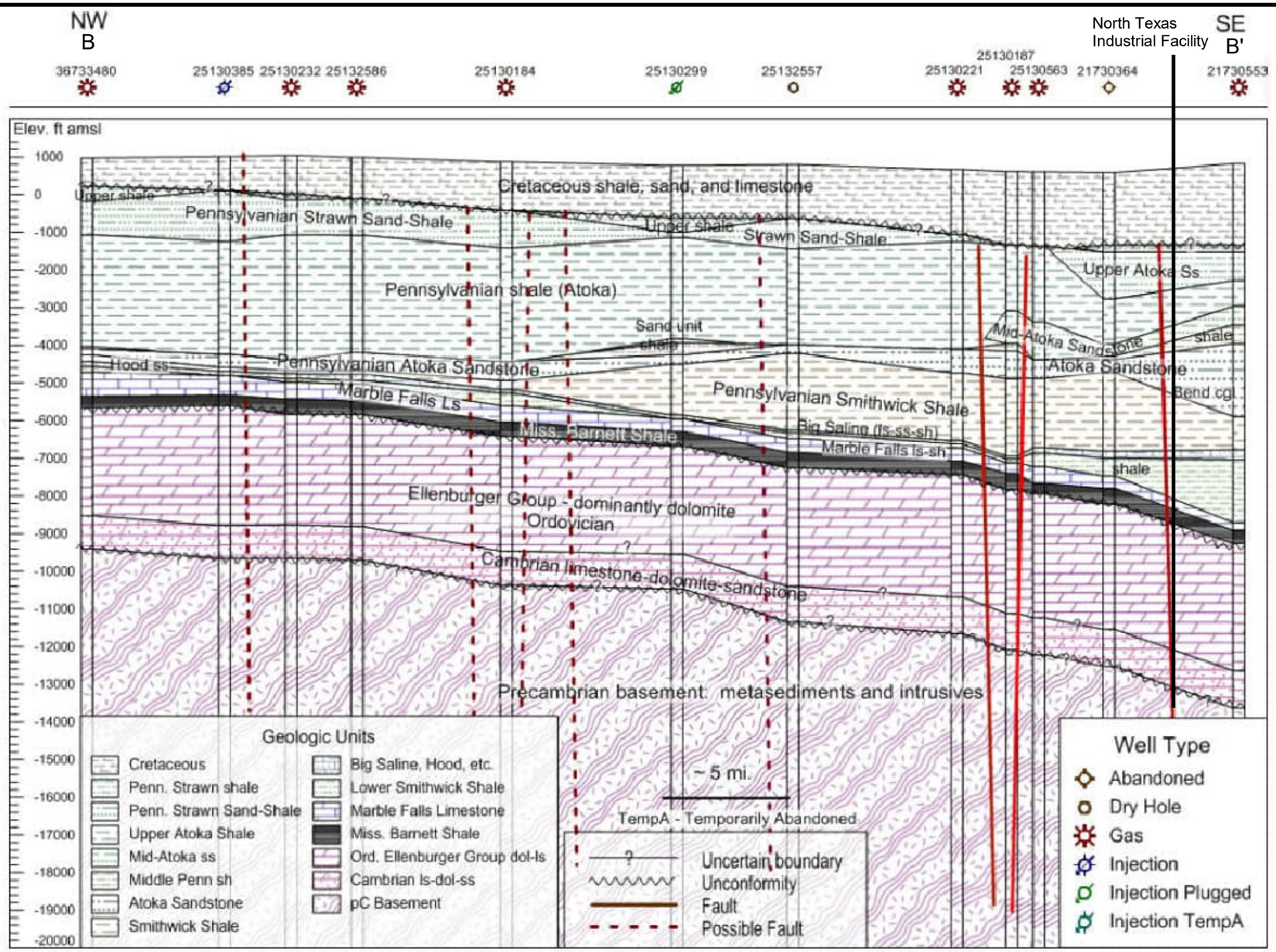
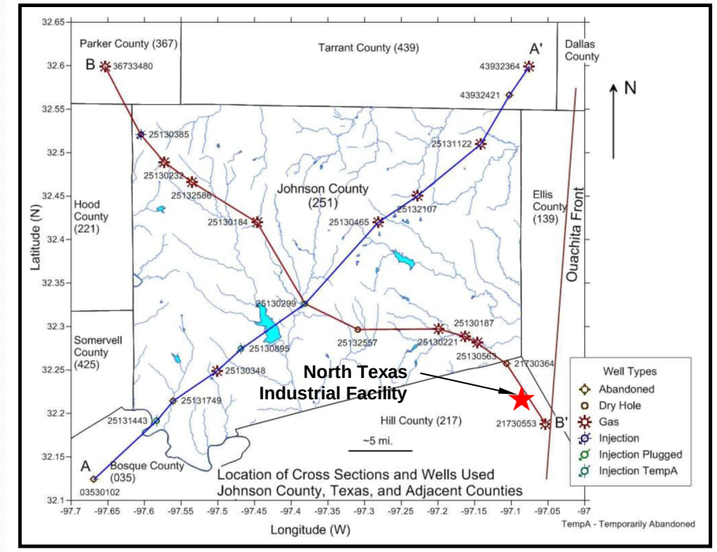
SOUTHWEST - NORTHEAST STRUCTURAL CROSS SECTION A-A', TARRANT COUNTY TO BOSQUE COUNTY, TEXAS

Job No. 192128M					
Drawn: WDD	Checked: MCM	Approved: EJB	Date: 11/07/2023	Scale: NONE	Figure No. V-2





Source: Figure 6, Geologic Characterization of Johnson County, Texas, NETL, Office of Fossil Energy, December 14, 2016, p. 27

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NORTH TEXAS INDUSTRIAL FACILITY
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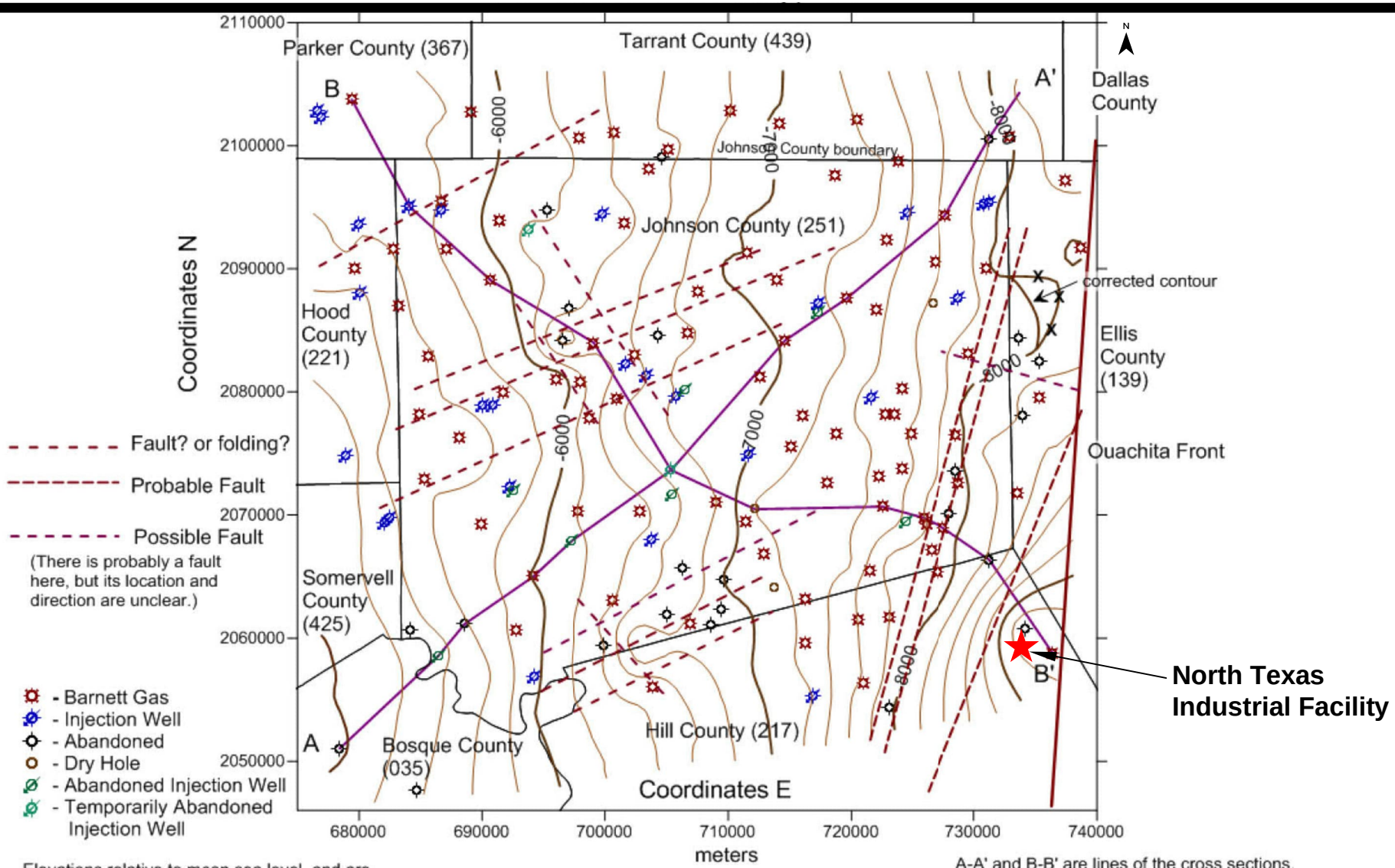
NORTHWEST - SOUTHEAST STRUCTURAL CROSS SECTION B-B', PARKER COUNTY TO HILL COUNTY, TEXAS

Job No. 192128M

Drawn: WDD	Checked: MCM	Approved: EJB	Date: 11/07/2023	Scale: NONE	Figure No. V-3



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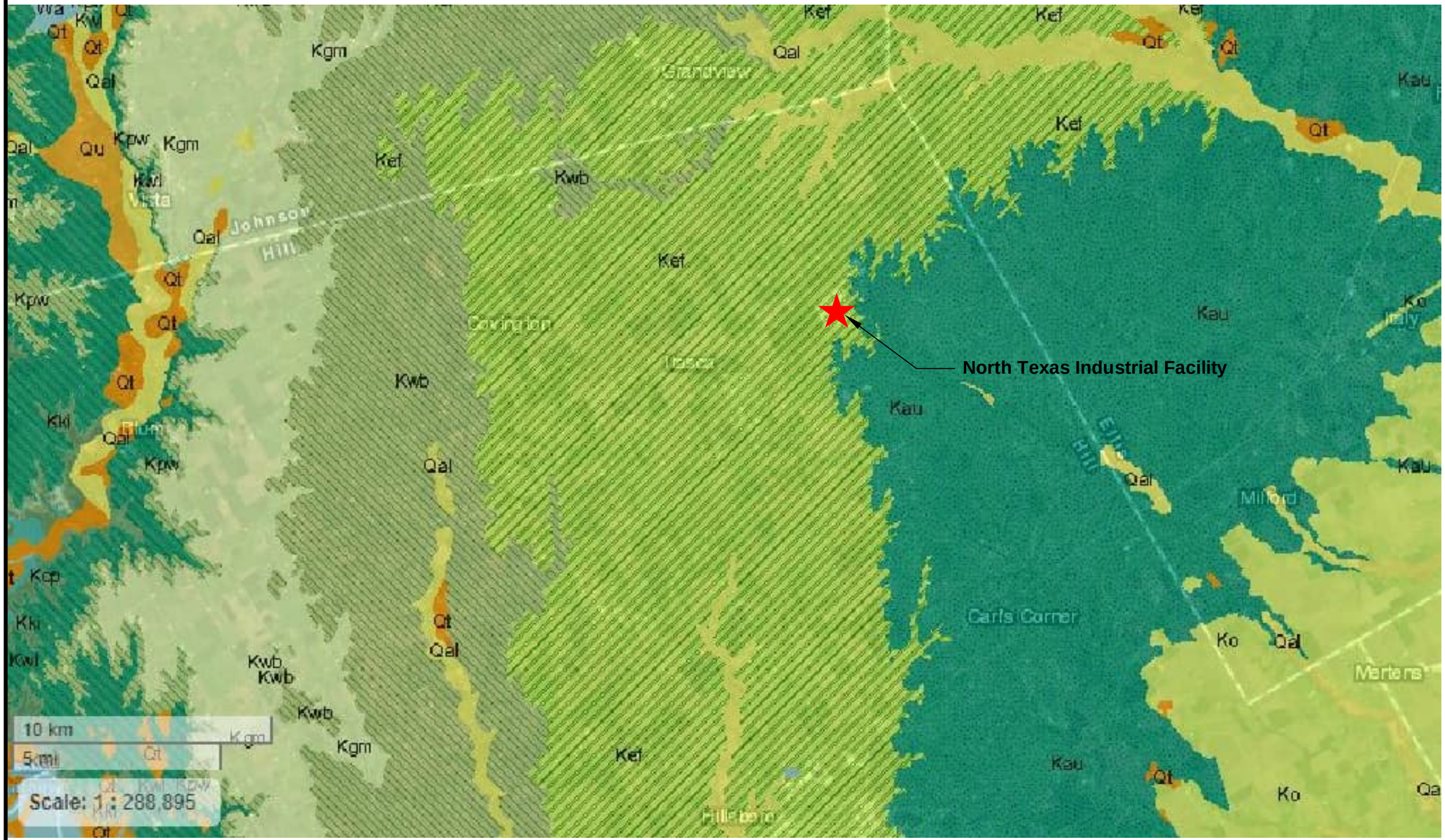
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

REGIONAL STRUCTURE MAP OF THE ELLENBURGER FORMATION

Job No. 192128M					
Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–4



LEGEND:

Kau	Austin Chalk
Kef	Eagle Ford Group
Kgm	Grayson Marl and Main Street Limestone undivided
Kki	Kiamichi Formation
Ko	Ozan Formation (lower Taylor marl)
Kpw	Pawpaw Formation and Upper Limestone Unit of Weno Limestone undivided
Kwb	Woodbrine Formation
Kwl	Middle Shale and Lower Limestone Units of Weno Limestone, Denton Clay, For Worth Limestone and Duck Creek Formation undivided
Qal	Alluvium
Qt	Fluviatile Terrace Deposits
Qu	Quaternary Deposits undivied

Source:https://txpub.usgs.gov/txgeology/

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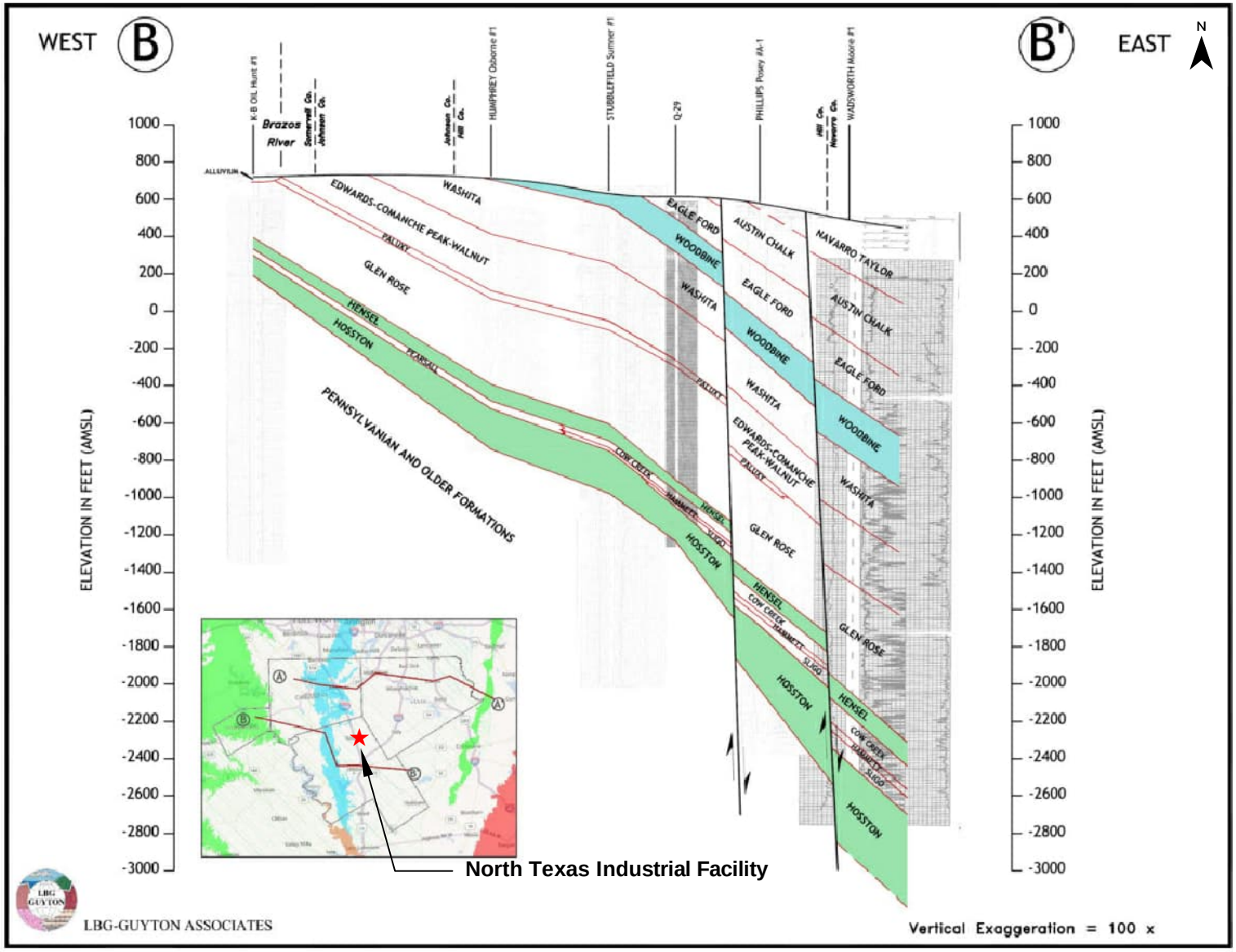
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SURFACE GEOLOGY OF NORTHEAST HILL COUNTY, TEXAS

Job No. 192128M

Drawn:	Checked:	Approved:	Date:	Scale:	Figure No.
WDD	MEC	EJB	11/07/2023	Above	V-5



Source: Prairie Lands Groundwater Conservation District Website - https://www.prairielandsgcd.org/about/"

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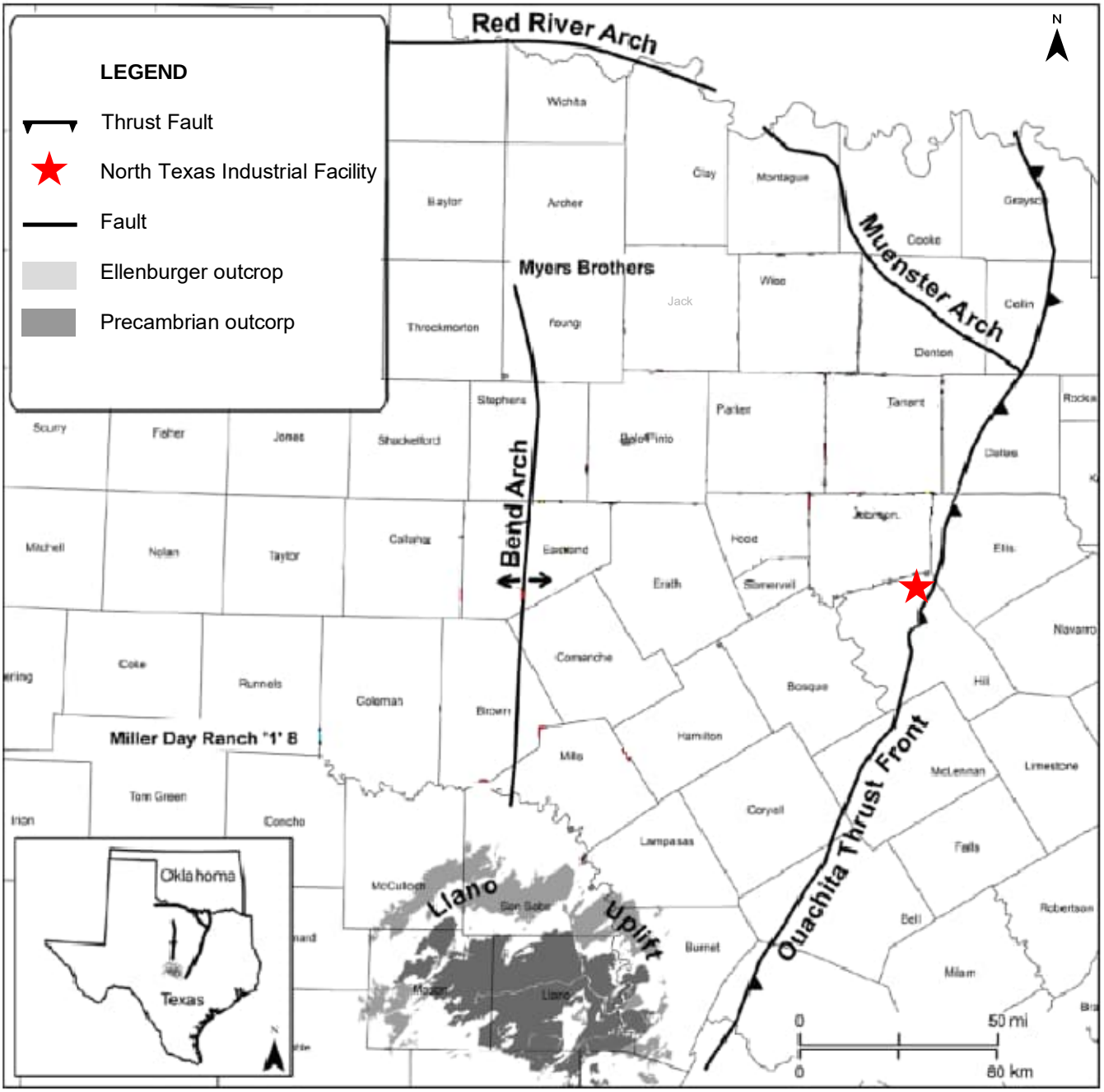
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

HYDROLOGIC STRUCTURAL CROSS SECTION B - B'

Job No.	192128M								
Drawn:	WDD	Checked:	MEC	Approved:	EJB	Date:	11/07/2023	Scale:	None
Figure No.	V–6								



Modified from " Smye et al., 2019"

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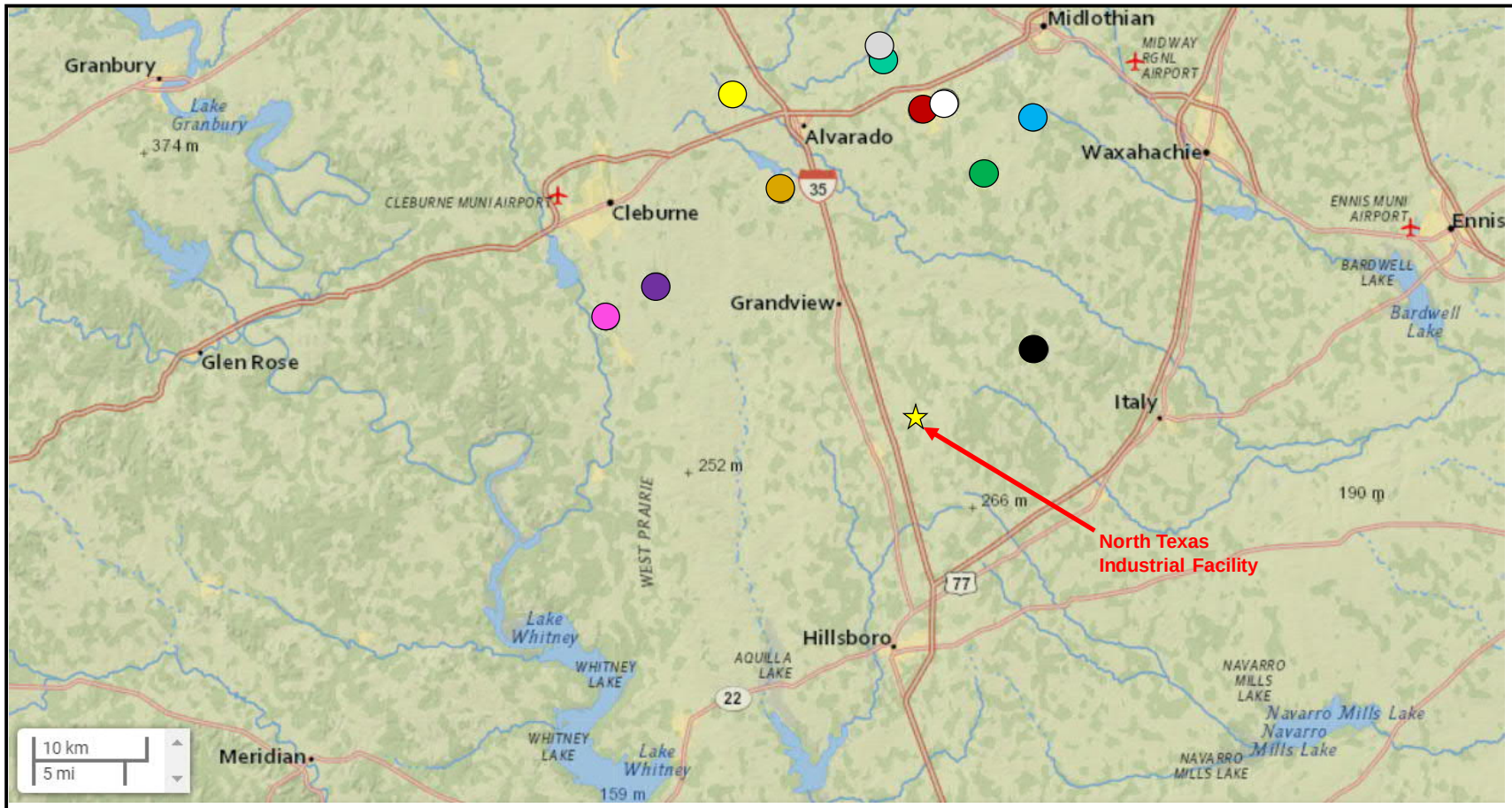
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

REGIONAL STRUCTURAL GEOLOGY OF THE FORT WORTH BASIN

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: Above	Figure No. V-7



- 2.7 northern Texas, 32.236°N 97.002°W, 2011-06-12 11:51:48 (UTC)
- 3.0 - northern Texas, 32.424°N 97.084°W, 2011-07-17 06:58:00 (UTC)
- 2.6 - 5km NW of Venus, Texas, 32.463°N 97.143°W, 2015-03-24 23:57:14 (UTC)
- 2.5 - northern Texas, 32.260°N 97.390°W, 2010-11-07 22:05:56 (UTC)
- 2.5 - northern Texas, 32.370°N 97.049°W, 2011-06-25 05:38:52 (UTC)
- 2.7 - northern Texas, 32.418°N 97.106°W, 2011-12-07 16:54:19 (UTC)
- 2.7 - northern Texas, 32.430°N 97.276°W, 2012-07-06 03:26:56 (UTC)
- 2.6 - northern Texas, 32.285°N 97.345°W, 2009-06-07 17:56:23 (UTC)
- 2.9 - northern Texas, 32.412°N 97.004°W, 2009-12-05 05:30:11 (UTC)
- 2.6 - 4km NW of Venus, Texas, 32.457°N 97.140°W, 2015-10-23 07:30:04 (UTC)
- 2.5 - northern Texas, 32.357°N 97.232°W, 2012-06-25 23:03:20 (UTC)

Source: USGS Earthquake Hazards Program, Earthquake Catalog, https://earthquake.usgs.gov/earthquakes/search/
Accessed: August 2020

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FIGURE V-8

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXS

SEISMICITY IN THE VICINITY OF THE SITE

DATED: 11/07/2023	APPROVED BY: MEC	JOB NO. 192128M
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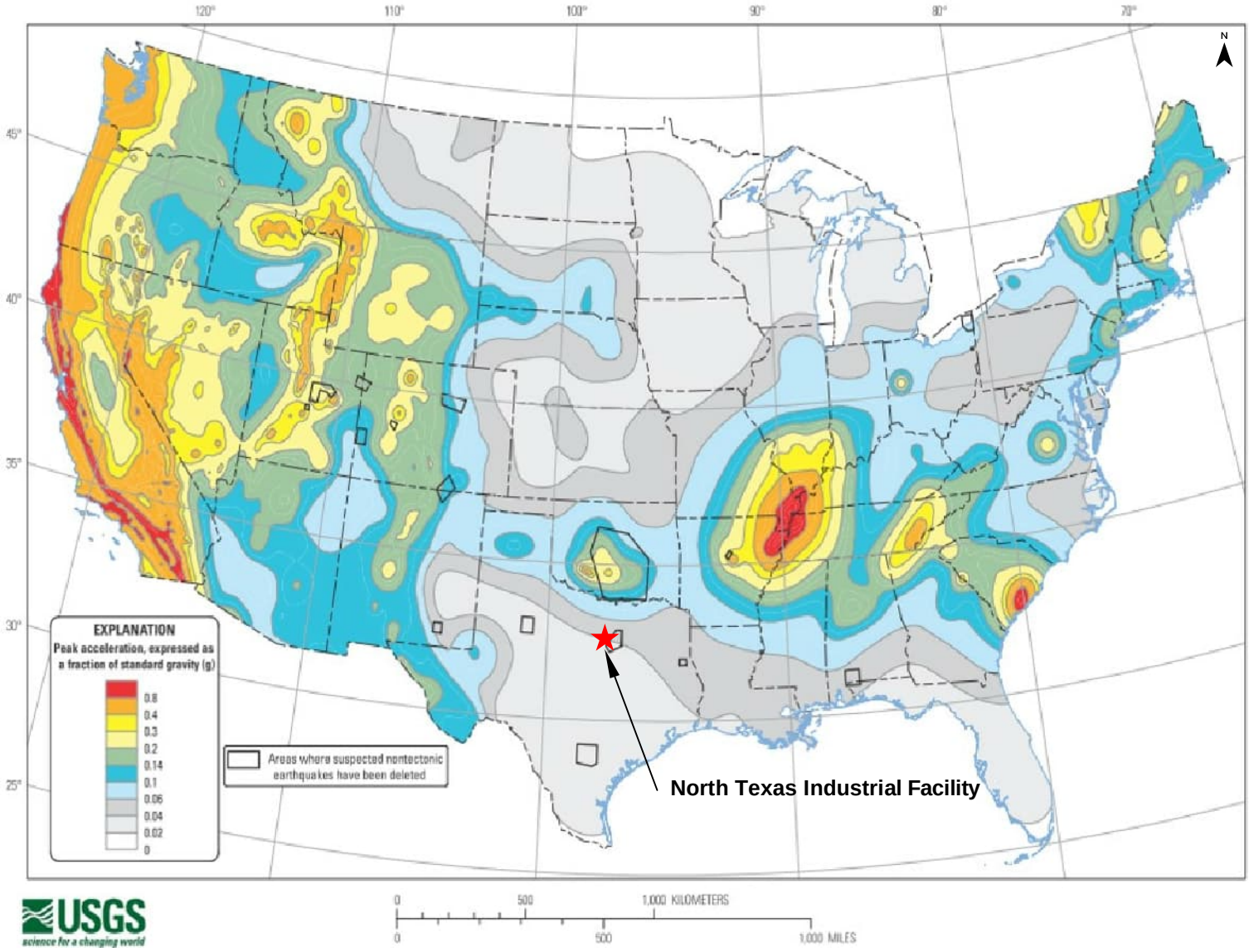

Two-percent probability of exceedance in 50 years map of peak ground acceleration

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NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC HAZARD MAP (2014)

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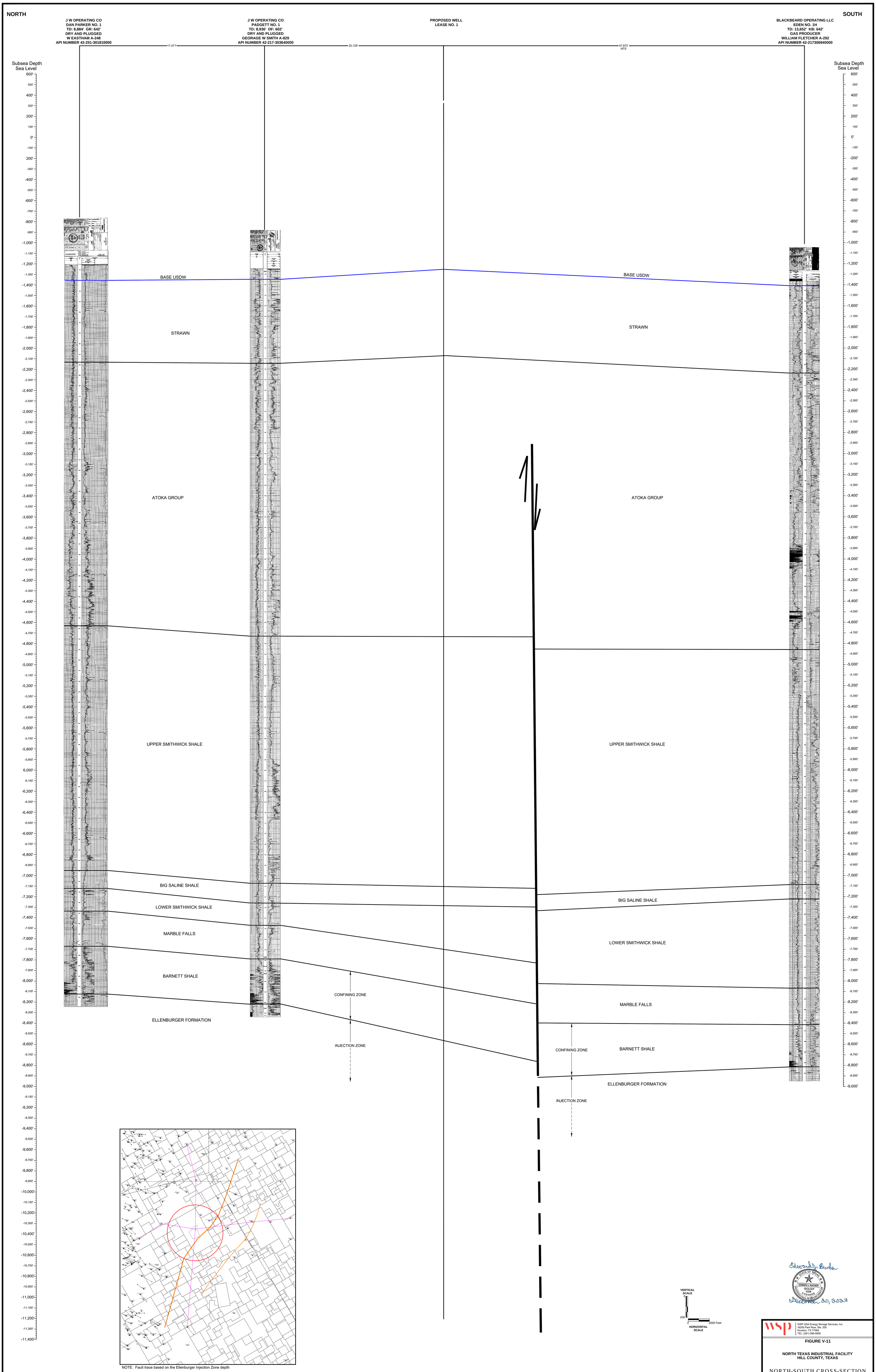
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

FACILITY LOCATION MAP

Job No. 192128M

Drawn:	Checked:	Approved:	Date:	Scale:	Figure No.
WDD	MEC	EJB	11/07/2023	ABOVE	V–10



NOTE: Fault trace based on the Ellenburger Injection Zone depth

STATE OF TEXAS
EDWARD J BUCHER
GEOLOGY
12339
LICENSED
PROFESSIONAL SEAL

December 20, 2023

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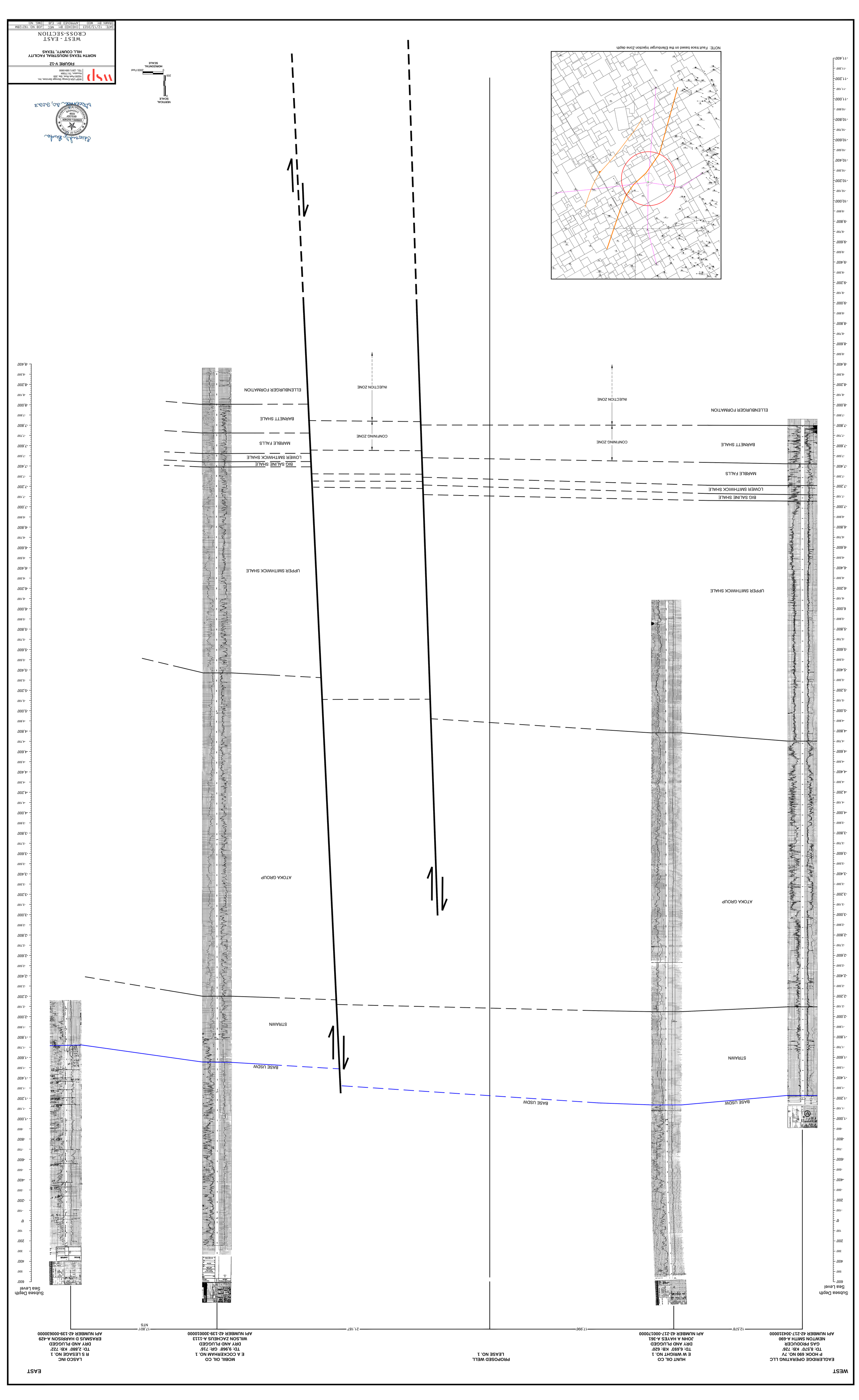
FIGURE V-11

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

NORTH-SOUTH CROSS-SECTION

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG. NO:



WEST
EAST
EAGLERIDGE OPERATING LLC
P HOOK 690 NO. 7V
TD: 8,570' KB: 726'
GAS PRODUCER
NEWTON SMITH A-690
API NUMBER 42-217-304310000
HUNT OIL CO
E W WRIGHT NO. 1
TD: 6,693' KB: 620'
DRY AND PLUGGED
JOHN A HAYES A-361
API NUMBER 42-217-000170000
PROPOSED WELL
LEASE NO. 1
MOBIL OIL CO
E A COCKERHAM NO. 1
TD: 9,968' GR: 716'
DRY AND PLUGGED
WILSON ZACHEUS A-1113
API NUMBER 42-139-300010000
LASCO INC
R S LESAGE NO. 1
TD: 2,880' KB: 722'
DRY AND PLUGGED
ERASMUS D HARRISON A-429
API NUMBER 42-139-000630000
12,578'
17,996'
21,187'
17,801'
NTS
Subsea Depth
Sea Level
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400'
200'
0'
-200'
-400'
-600'
-800'
-1,000'
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-1,400'
-1,600'
-1,800'
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-7,600'
-7,800'
-8,000'
-8,200'
-8,400'
-8,600'
-8,800'
-9,000'
-9,200'
-9,400'
-9,600'
-9,800'
-10,000'
-10,200'
-10,400'
-10,600'
-10,800'
-11,000'
-11,200'
-11,400'
BASE USDW
STRAWN
ATOKA GROUP
UPPER SMITHWICK SHALE
BIG SALINE SHALE
LOWER SMITHWICK SHALE
MARBLE FALLS
BARNETT SHALE
ELLENBURGER FORMATION
CONFINING ZONE
INJECTION ZONE
VERTICAL SCALE
0
200
0
2000 Feet
HORIZONTAL SCALE

NOTE: Fault trace based on the Ellenburger Injection Zone depth

Edward J. Bucher

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December 20, 2023

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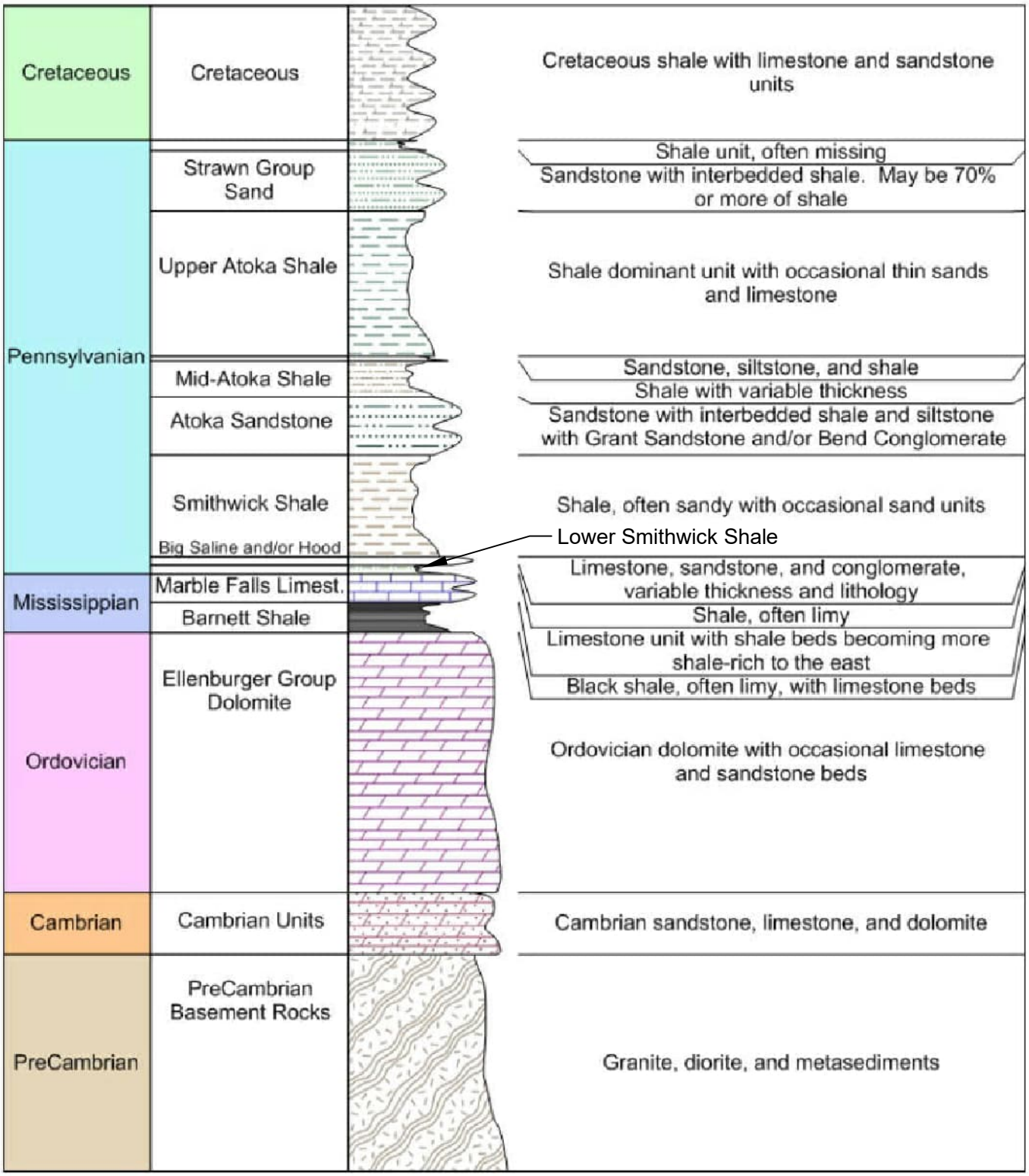
FIGURE V-12

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

WEST - EAST CROSS-SECTION

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG. NO:



Modified From: Figure 3, Geologic Characterization of Johnson County, Texas, NETL, Office of Fossil Energy, December 14, 2016, p. 22

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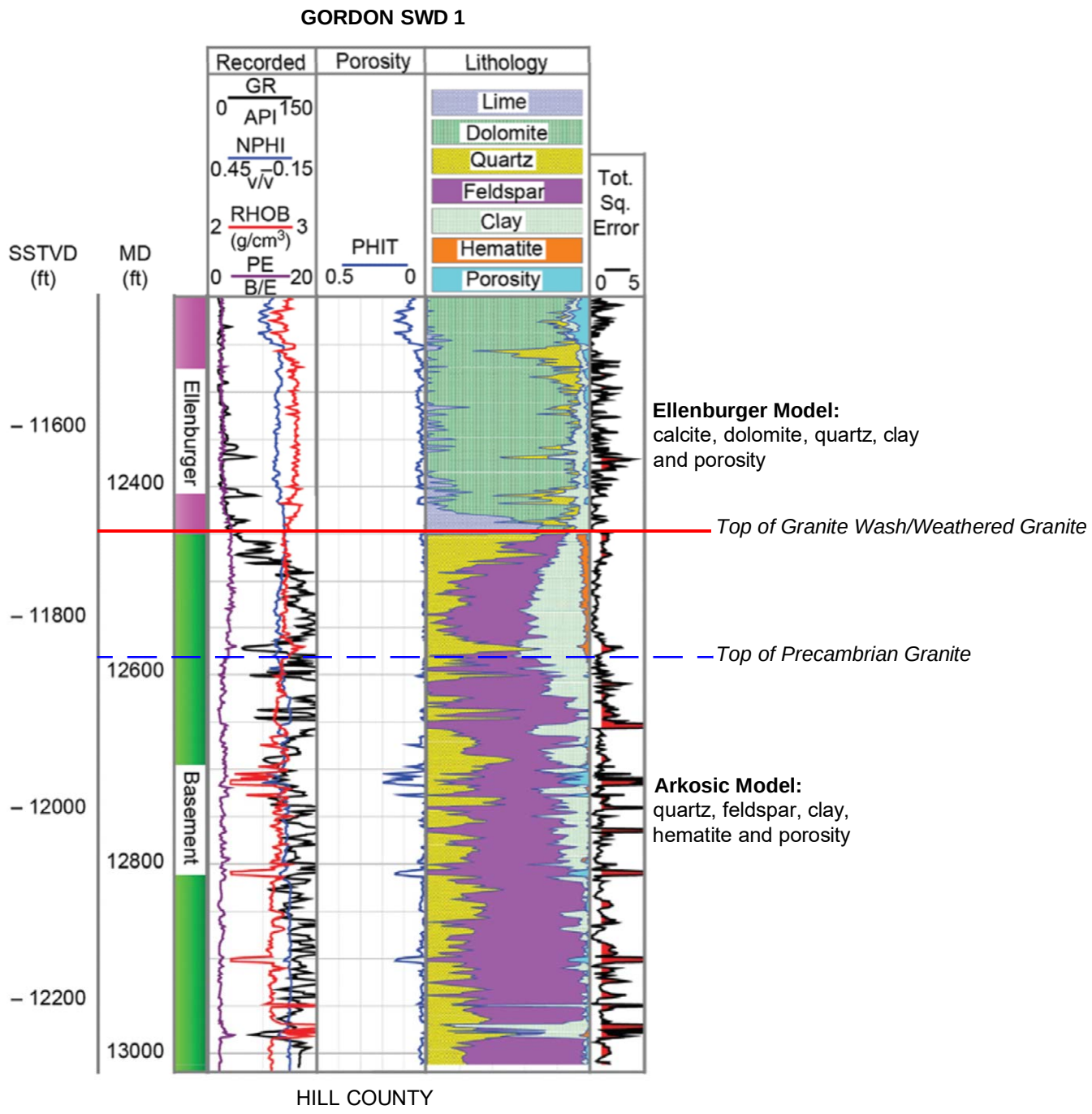
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SITE GEOLOGIC AND HYDROLOGIC UNITS

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: NONE	Figure No. V–13



Modified from " Smye et al., 2019"

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NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

EOG RESOURCES GORDON SWD 1 WELL DETAILED LOG ANALYSIS

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–14

ERA	SYSTEM	SERIES	GROUP	STRATIGRAPHIC UNITS			THICKNESS (feet)		CHARACTER OF ROCKS		WATER-BEARING CHARACTERISTICS	
Mesozoic	Cretaceous	Comanche	Fredericks-burg				0-160		Limestone, shale, and clay.		Yields small quantities of water to shallow wells.	
			Trinity	Antlers Formation	Paluxy Formation		0-250	0-100	Sand, gravel, shale, sandstone, and clay.	Sand, shale, and clay.	Yields moderate quantities of water to wells.	Yields small quantities of fresh to slightly saline water to wells.
					Glen Rose Formation			0-330		Limestone, marl, shale, and clay, with sand lenses.		Yields small quantities of water to shallow wells in localized areas.
					Travis Peak Formation (Twin Mountains Formation)	Hensell Member (Upper Unit)		0-185		Fine to coarse-grained sand, gravel, sandstone, shale, and clay.		Yields small to moderate quantities of fresh to slightly saline water.
						Pearsall Member (Middle Unit)		0-60		Clay, sandy clay, shale, and local sand lenses.		Yields no water or only small amounts along the outcrop.
						Hosston Member (Lower Unit)		0-125		Medium to coarse-grained sand, gravel, sandstone, shale, clay, and conglo-merate (siliceous).		Yields moderate to large quantities of fresh to slightly saline water.

Source: Ground-Water Resources of the Antlers and Travis Peak Formations in the Outcrop Area of North-Central Texas. (Nordstrom, 1982)

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NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–15

API No. 217-30457

KB Elevation = 745' AMSL
(KB = 18' above ground level)

Proposed WDW-457

Ground Level Elevation = 720' AMSL

~9.25 Miles

DEPTHS, KB

DEPTHS, GL

8,322'

Top of Injection Zone = 8,645' (Top of Ellenburger)
8,645' SEISMIC DEPTH = 7,900' BMSL

8,894'

9,172' - 9,185' (13')
9,196' - 9,200' (4')

9,270' - 9,275' (5')
9,316' - 9,322' (6')

9,532' - 9,538' (6')
9,575' - 9,581' (6')

9,775' - 9,790' (15')

9,856' - 9,867' 11')
9,890' - 9,894' (4')
9,926' - 9,828' (2')
9,948' - 9,860' (2')

9,991' - 9,994' (3')
10,029' - 10,031' (2')

10,422' - 10,424' (2')

10,595' - 10,606' (11')
10,617' - 10,619' (2')
10,641' - 10,651' (10')
10,658' - 10,668' (10')

2' 11,132' - 11,134' (2')

20' 11,240' - 11,260' (20')

5' 11,640' - 11,645' (5')

7' 11,712' - 11,714' (2')
11,720' - 11,725' (5')
5' 11,758' - 11,763' (5')

4' 11,836' - 11,840' (4')
5' 11,855' - 11,860' (5')

5' 12,165' - 12,170' (5')
12,219' - 12,229' (10')
12,230' - 12,240' (10')
29' 12,249' - 12,258' (9')

196' TOTAL ESTIMATED HEIGHT

Top of Lower Confining Zone = 12,320'

Top of Lower Confining Zone = 12,458'
(Top of Cambrian Granite Wash)

Upper Confining Zone

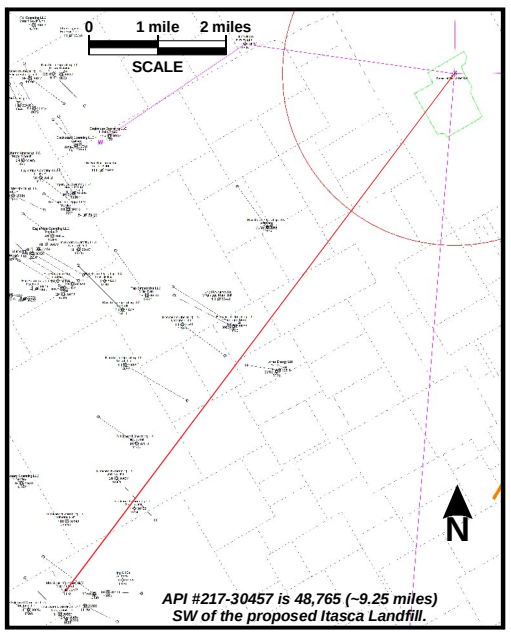
Top of Confining Zone (Top Barnett Shale) = 8,260'

Top of Injection Zone (Top of Ellenburger) = 8,520'
SEISMIC DEPTH = 7,800' BMSL

Injection Zone

Injection Interval

Lower Confining Zone



LEGEND

- Porosity > 6%
- Limestone Formation

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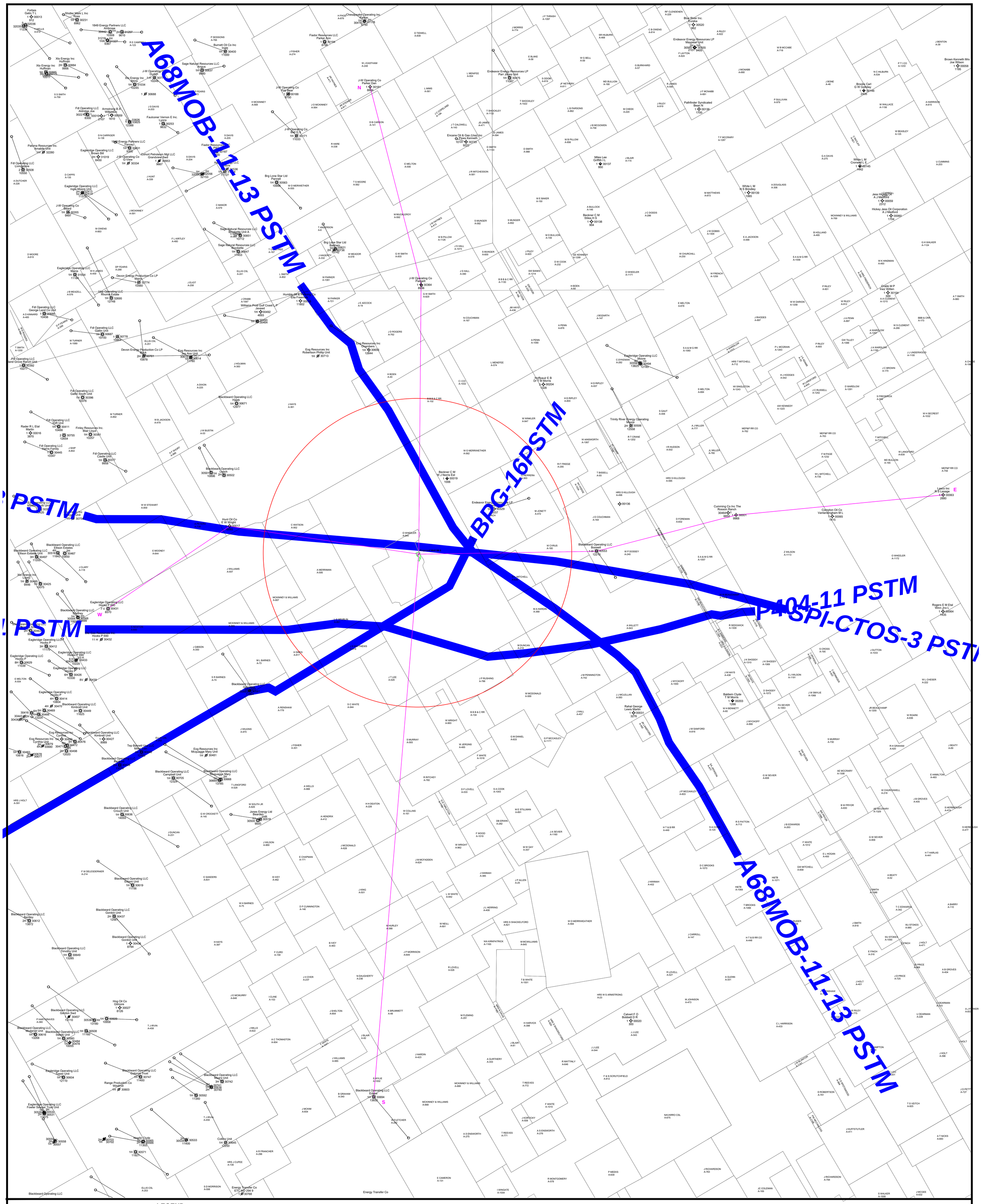
FIGURE V-16

NORTH TEXAS INDUSTRIAL FACILITY
ITASCA, HILL COUNTY, TEXAS

ANNOTATED LOG SHOWING PROPOSED REGULATORY ZONE AND PROJECTED INJECTION RESERVOIRS

DATE 11/07/2023	CHECKED BY JHL	JOB NO. 192128M	
DRAWN BY SLK	APPROVED BY EJB	DWG NO.	



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- FAULT

-N-

API Number
Well Number
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

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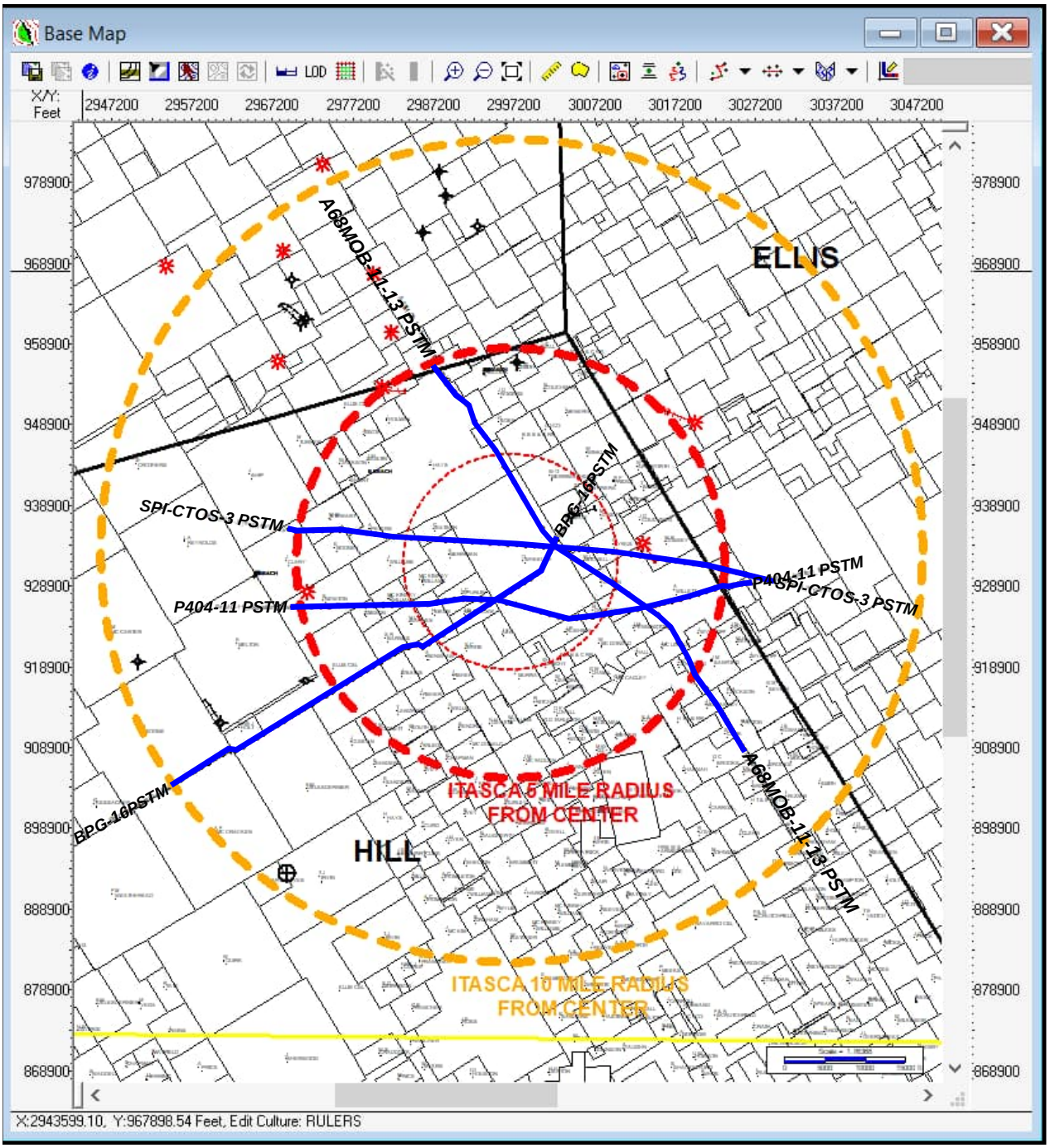
FIGURE V-17

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

UNINTERPRETED BASE MAP

DATE: 11/07/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:



Modified from Hill, Kevin B., 2023 Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana, 26 p.

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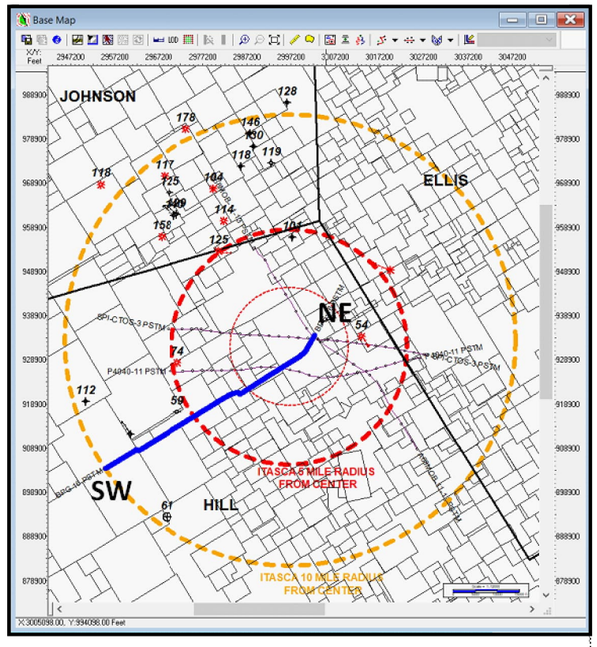
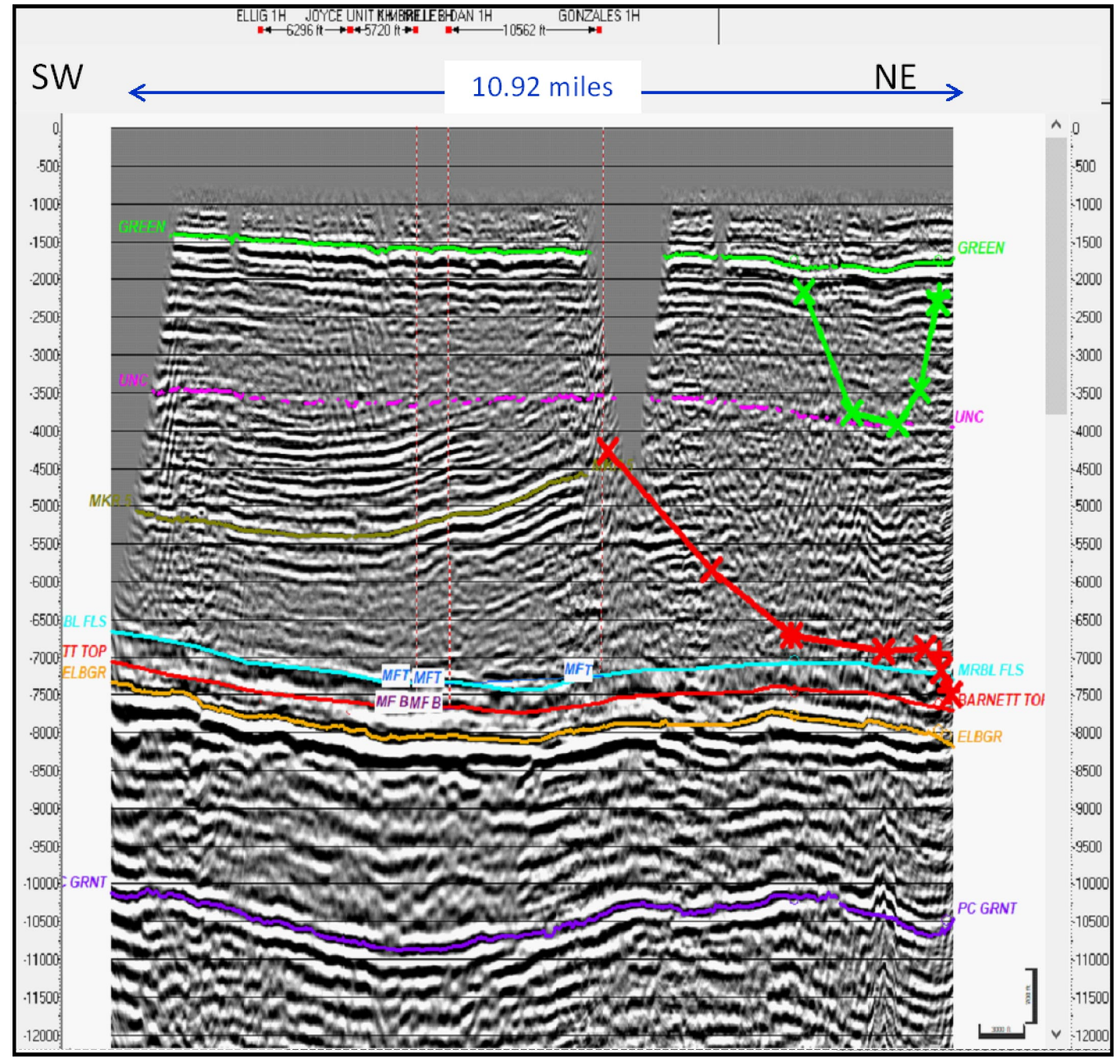
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

MAP SHOWING LOCATIONS OF 2D SEISMIC LINES

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: Above	Figure No. V–18





Modified from: Hill, Kevin B., 2023, Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana, 26 p.

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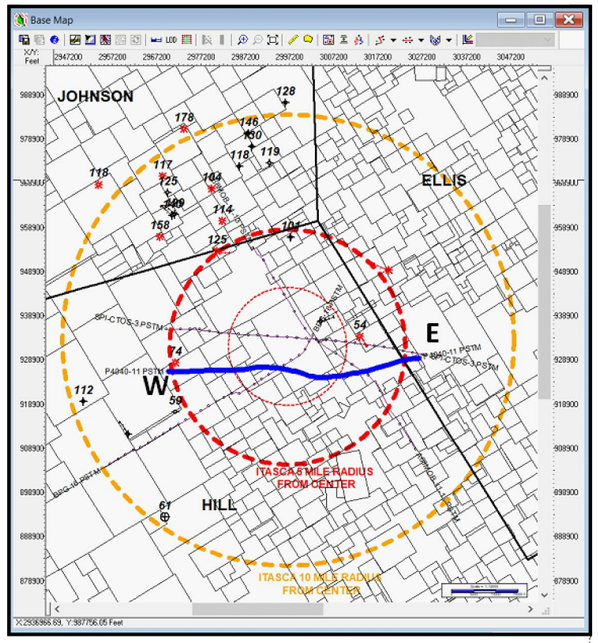
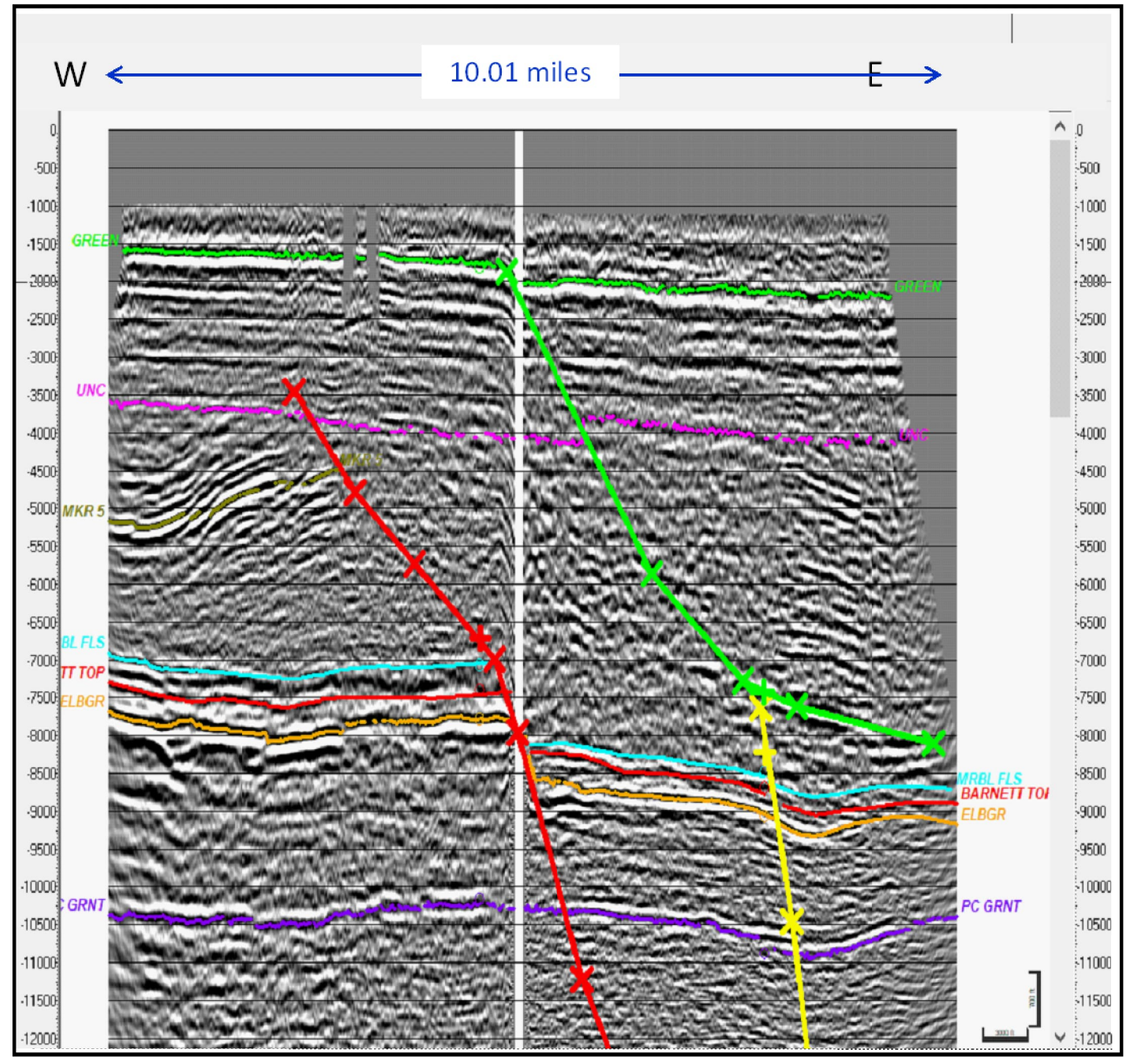
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC PROFILE SW-NE 2D SEISMIC LINE BPG-16

Job No. 192128M

Drawn:	Checked:	Approved:	Date:	Scale:	Figure No.
WDD	MEC	EJB	11/07/2023	None	V–19





Modified from: Hill, Kevin B., 2023, Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana.

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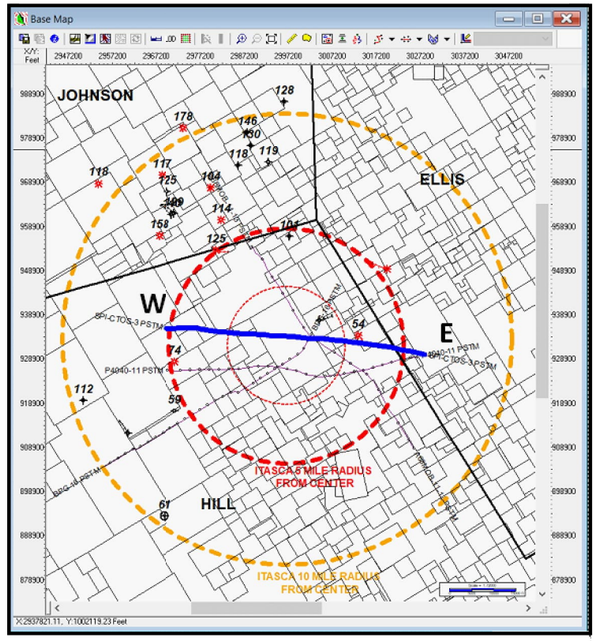
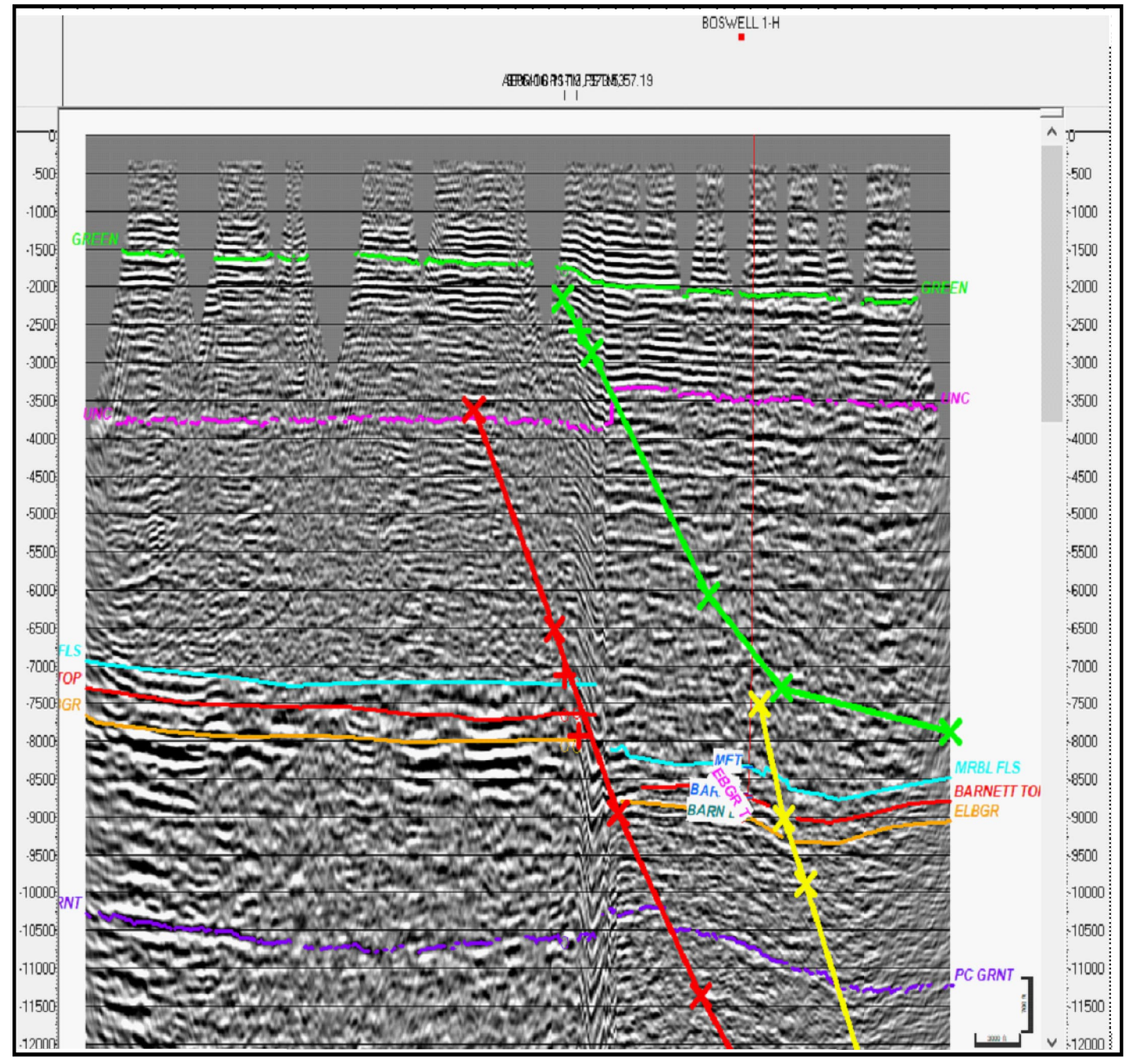
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC PROFILE WEST-EAST 2D SEISMIC LINE P4040-11

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–20





Modified from: Hill, Kevin B., 2023, Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana.

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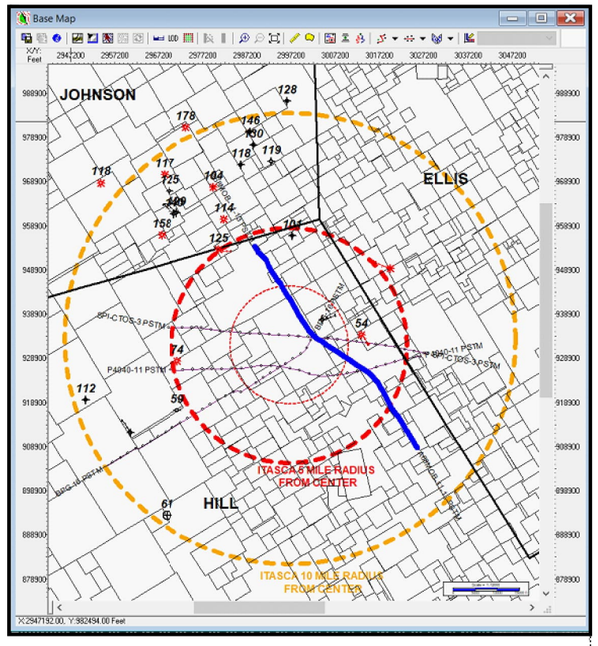
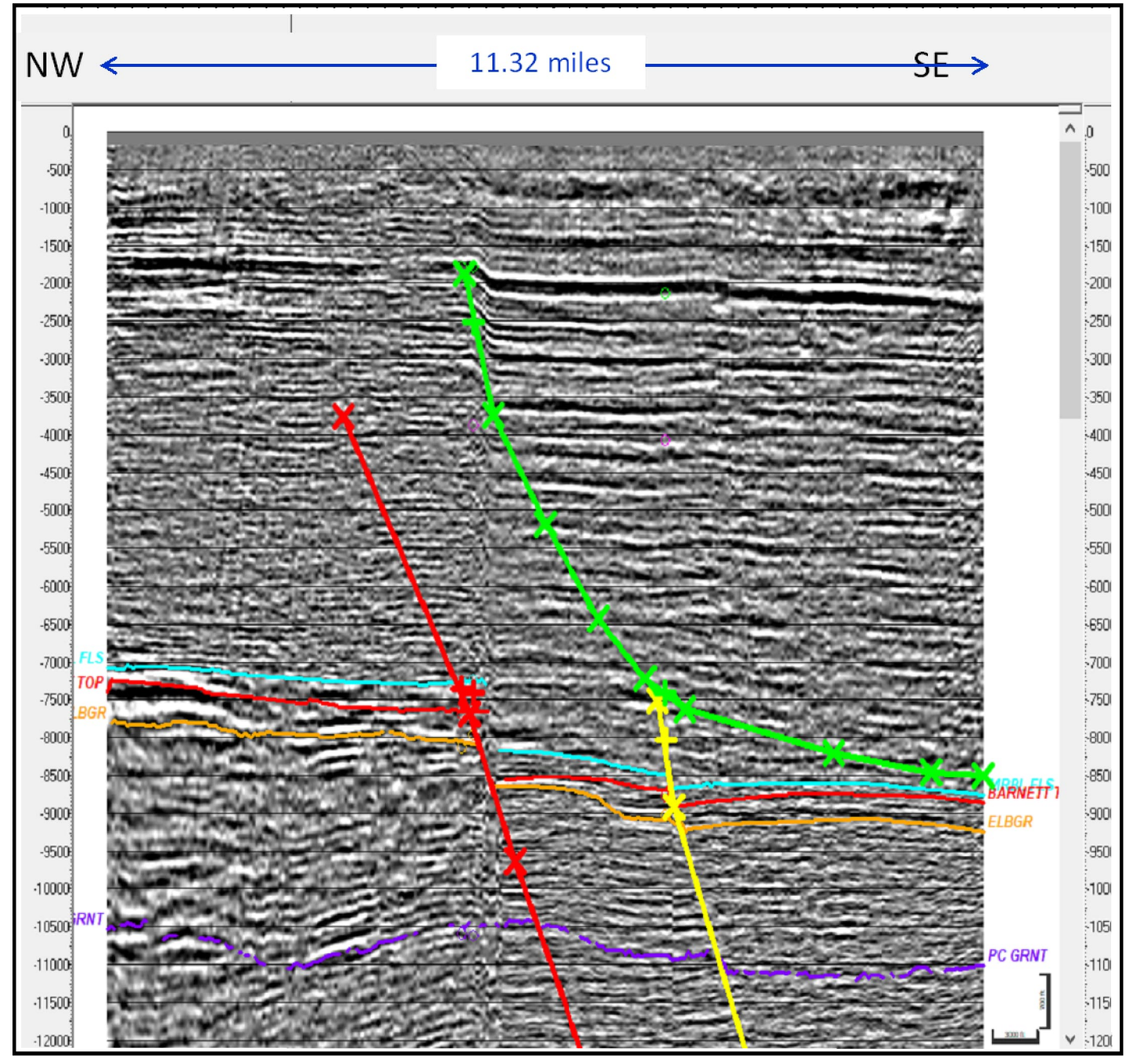
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC PROFILE WEST-EAST 2D SEISMIC LINE SPI-CTOS-3

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–21





Modified from: Hill, Kevin B., 2023, Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana.

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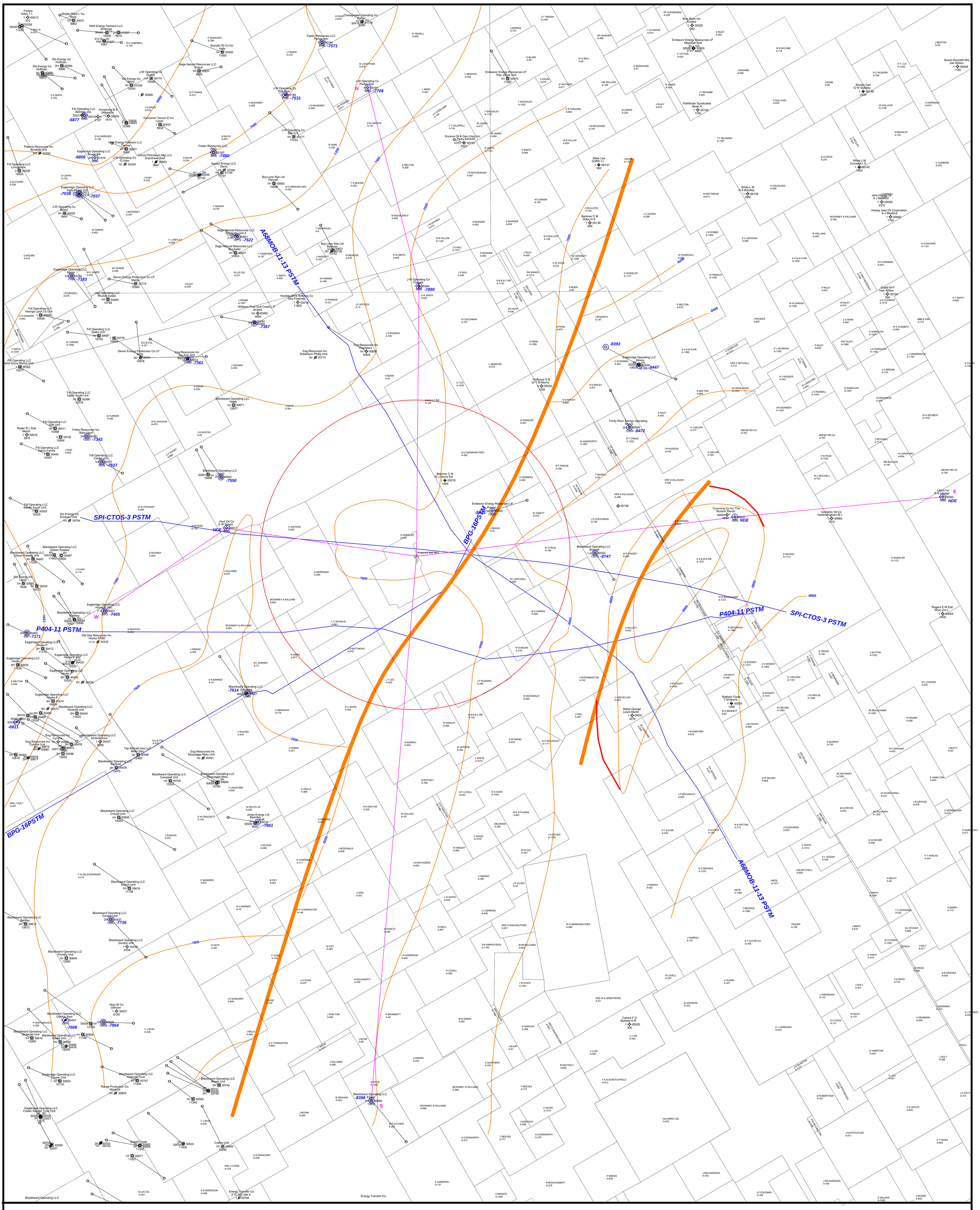
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC PROFILE NW-SE 2D SEISMIC LINE A68MOB11-13

Job No. 192128M

Drawn: WDD	Checked: MEC	Approved: EJB	Date: 11/07/2023	Scale: None	Figure No. V–22



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- STRUCTURAL CONTOUR OF THE BARNETT SHALE UPPER CONFINING ZONE (FT BMSL)
- FAULT
- 2D SEISMIC LINES

API Number

Well Number — 1H 30529 12037 -8435 — Depth to Barnett Shale Upper Confining Zone (ft BMSL)

Total Depth of Well

SCALE (IN FEET)

0 2000 4000

CONTOUR INTERVAL = 200 ft.

Prepared By: Edward J. Bucher, Sr. Geologist of WSP USA Inc., and revised from original Kevin B. Hill work effort dated 10/26/2023 (see Appendix V-4).

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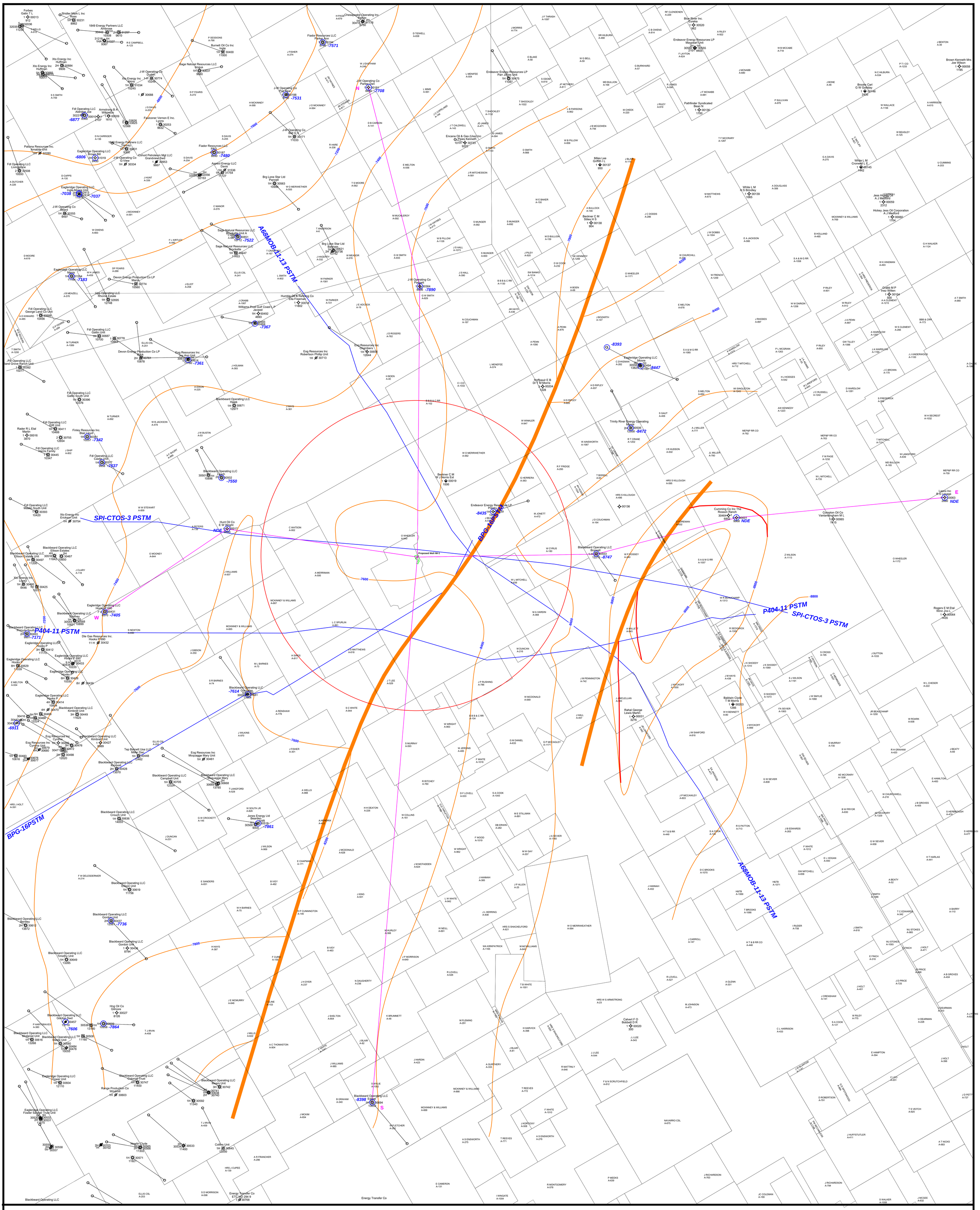
FIGURE V-23

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC STRUCTURE MAP OF THE BARNETT SHALE UPPER CONFINING ZONE

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- STRUCTURAL CONTOUR OF THE BARNETT SHALE UPPER CONFINING ZONE (FT BMSL)
- FAULT
- 2D SEISMIC LINES

-N-

API Number
Well Number
-8435 Depth to Barnett Shale Upper Confining Zone (ft BMSL)
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

CONTOUR INTERVAL = 200 ft.

Prepared By: Edward J. Bucher, Sr. Geologist of WSP USA Inc., and revised from original Kevin B. Hill work effort dated 10/26/2023 (see Appendix V-4).

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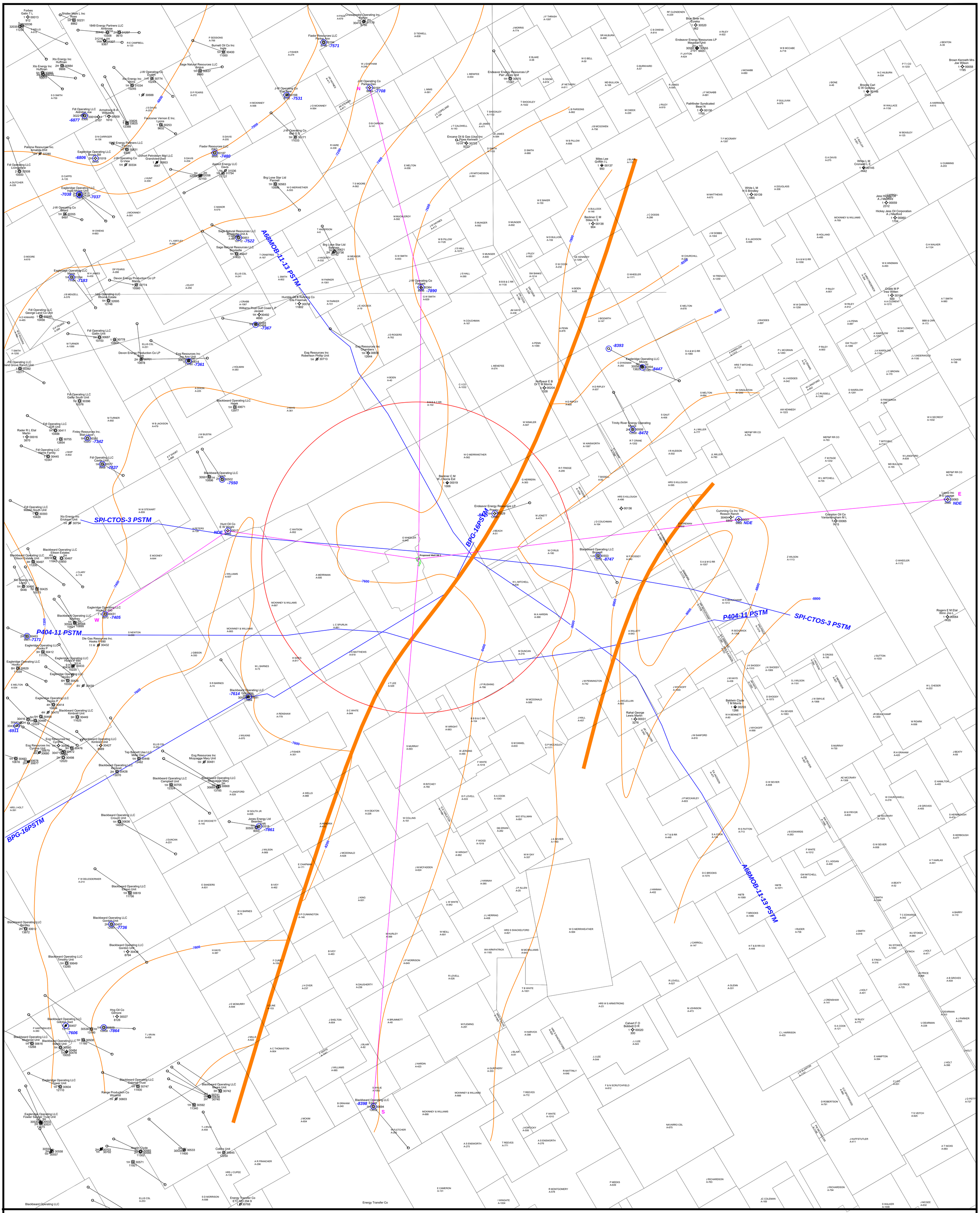
FIGURE V-23

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC STRUCTURE MAP OF THE BARNETT SHALE UPPER CONFINING ZONE

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- STRUCTURAL CONTOUR OF THE BARNETT SHALE UPPER CONFINING ZONE (FT BMSL)
- FAULT
- 2D SEISMIC LINES

API Number

Well Number — -8435 — Depth to Barnett Shale Upper Confining Zone (ft BMSL)

Total Depth of Well

SCALE (IN FEET)

0 2000 4000

CONTOUR INTERVAL = 200 ft.

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STATE OF TEXAS
EDWARD J. BUCHER
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PROFESSIONAL

December 20, 2023

Prepared By: Edward J. Bucher, Sr. Geologist of WSP USA Inc., and revised from original Kevin B. Hill work effort dated 10/26/2023 (see Appendix V-4).

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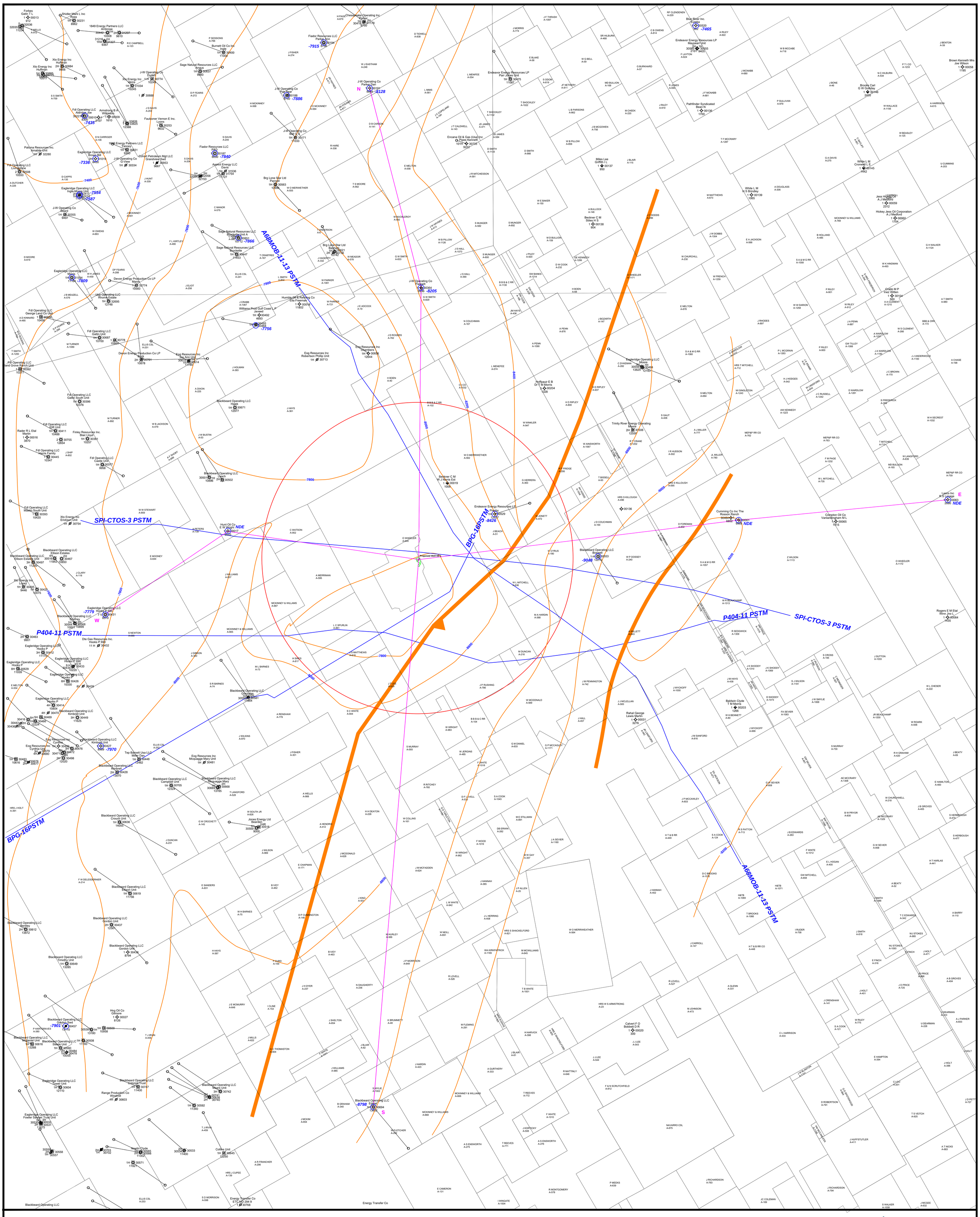
FIGURE V-23

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC STRUCTURE MAP OF THE BARNETT SHALE UPPER CONFINING ZONE

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- STRUCTURAL CONTOUR OF THE ELLENBURGER FORMATION INJECTION ZONE (FT BMSL)
- FAULT
- 2D SEISMIC LINES

-N-

API Number

Well Number — 1H 00209 — -8426 — Depth to Ellenburger Formation Injection Zone (ft BMSL)

Total Depth of Well

SCALE (IN FEET)

0 2000 4000

CONTOUR INTERVAL = 200 ft.

STATE OF TEXAS — EDWARD J. BUCHER — GEOLOGY — 7339 — LICENSED — PROFESSIONAL SEAL

December 20, 2023

Prepared By: Edward J. Bucher, Sr. Geologist of WSP USA Inc., and revised from original Kevin B. Hill work effort dated 10/26/2023 (see Appendix V-4).

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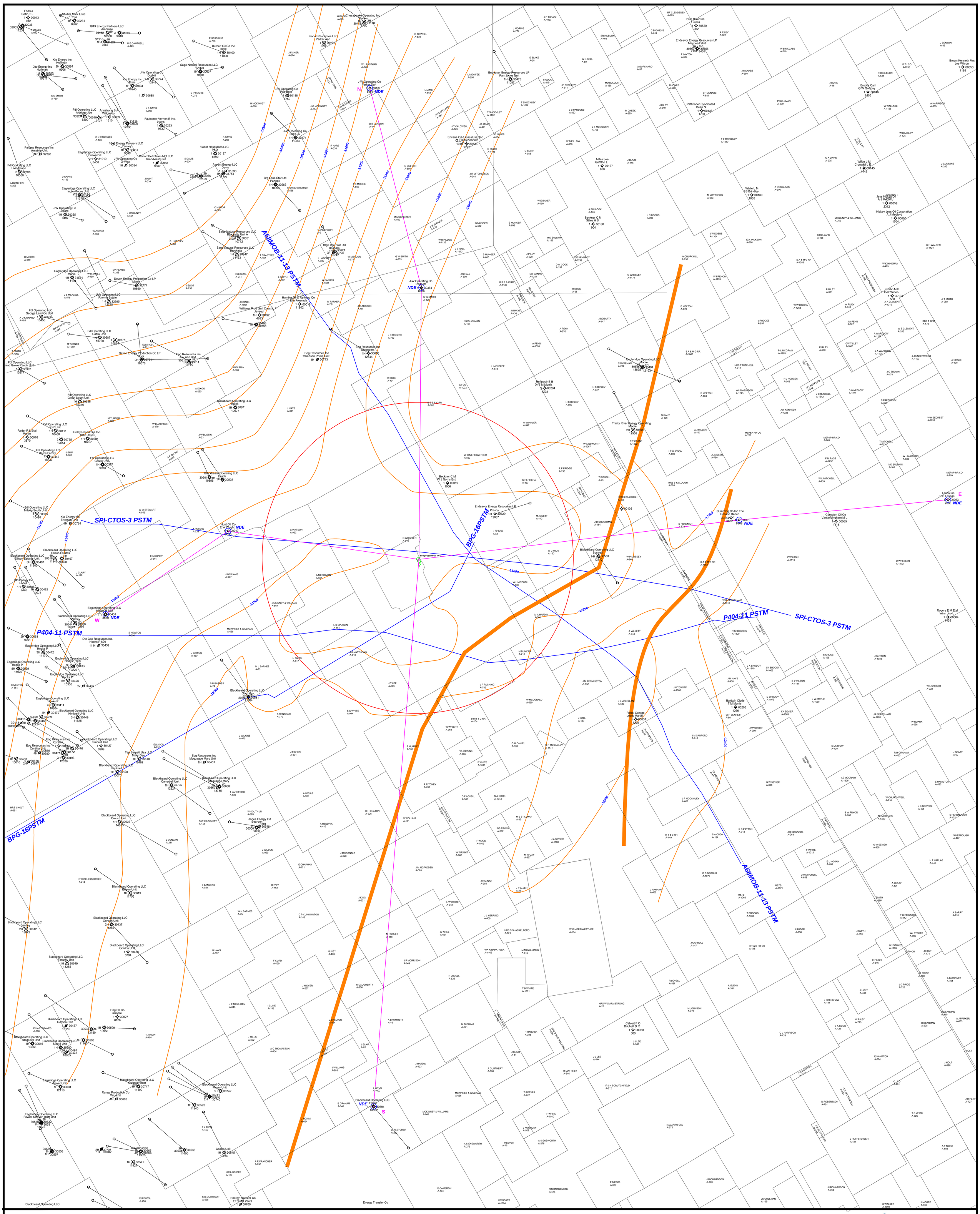
FIGURE V-24

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC STRUCTURE MAP OF THE ELLENBURGER FORMATION INJECTION ZONE

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- STRUCTURAL CONTOUR OF THE PRE CAMBRIAN GRANITE LOWER CONFINING ZONE (FT BMSL)
- FAULT
- 2D SEISMIC LINES

API Number
Well Number
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

CONTOUR INTERVAL = 200 ft.

Edward J. Bucher
STATE OF TEXAS
EDWARD J. BUCHER
GEOLOGY
12329
LICENSED
December 20, 2023

Prepared By: Edward J. Bucher, Sr. Geologist of WSP USA Inc., and revised from original Kevin B. Hill work effort dated 10/26/2023 (see Appendix V-4).

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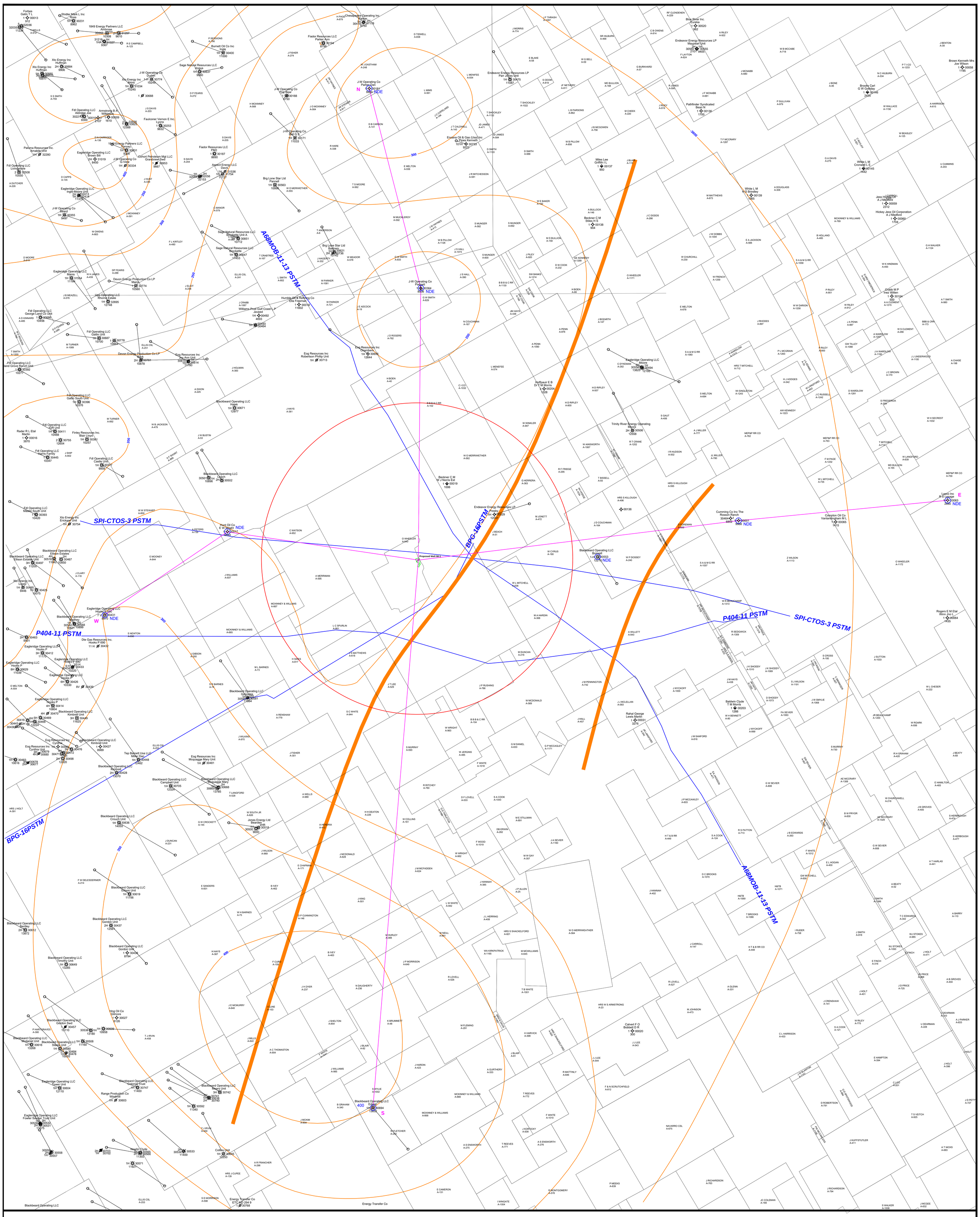
FIGURE V-25

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

SEISMIC STRUCTURE MAP OF THE PRECAMBRIAN GRANITE LOWER CONFINING ZONE

DATE: 11/07/2023	CHECKED BY: MEC	JOB NO: 192128M	
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:	



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- NET ISOPACH OF THE CONFINING ZONE (FT)
- FAULTS
- 2D SEISMIC LINES

API Number
Well Number
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

CONTOUR INTERVAL = 50 ft.

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December 30, 2023

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FIGURE V-26

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

ISOPACH MAP OF THE CONFINING ZONE FROM SEISMIC DATA

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
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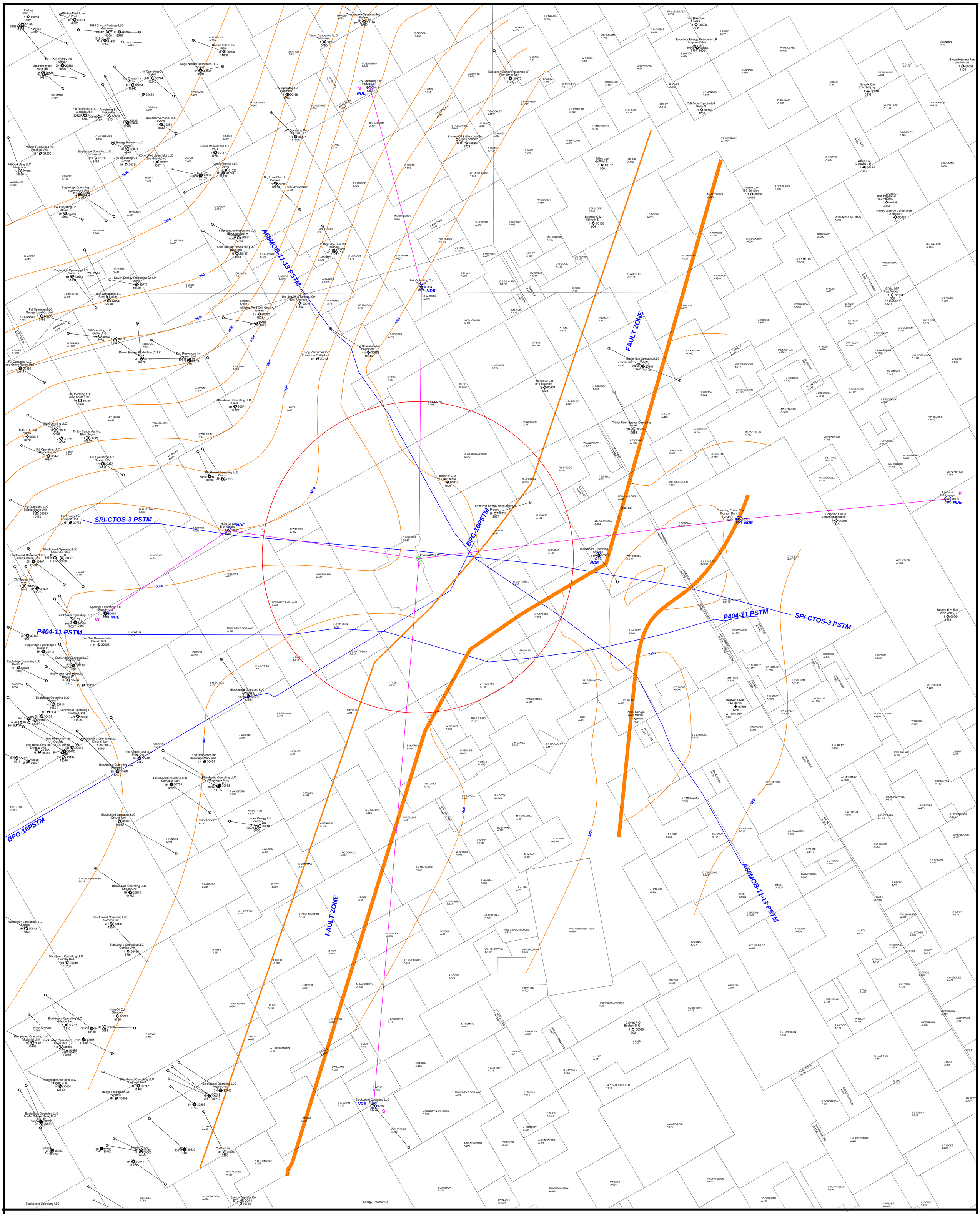

LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- NET ISOPACH OF THE INJECTION ZONE (FT)
- FAULT or OUACHITA THRUST FRONT
- 2D SEISMIC LINES

-N-

API Number
Well Number
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

CONTOUR INTERVAL = 200 ft.

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FIGURE V27

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

ISOPACH MAP OF THE INJECTION ZONE FROM SEISMIC DATA

DATE: 12/13/2023	CHECKED BY: MEC	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: EJB	DWG NO:

APPENDICES

APPENDIX

V-1 Research Paper on Ellenburger Waste-water Injection and Seismicity in North Texas

(Hornbach et al., 2016)

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Ellenburger wastewater injection and seismicity in North Texas

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ABSTRACT

North Texas has experienced a roughly exponential increase in seismicity since 2008. This increase is primarily attributable to wastewater injection into the Ellenburger Formation—a carbonate formation located within and just above seismically active zones. To our knowledge, there has been no previous comprehensive ~10 year analysis comparing regional seismicity with basin-wide injection and injection pressure of wastewater into the Ellenburger, even though monthly injection/pressure records have been made publically available for nearly a decade. Here we compile and evaluate more than 24,000 monthly injection volume and pressure measurements for the Ellenburger formation. We compare Ellenburger injection pressures and volumes to basin-wide injection pressures and volumes, and to earthquake locations and rates. The analysis shows where cumulative injection volumes are highest, where injection pressures and formation pressures are increasing, how injection volumes have changed regionally with time, and how Ellenburger injection volumes and pressures correlate in space and time with recent seismicity in North Texas. Results indicate that between 2005 and 2014 at least 270 million m^3 (~1.7 billion barrels) of wastewater were injected into the Ellenburger formation. If we assume relative homogeneity for the Ellenburger and no significant fluid loss across the 63,000 km^2 basin, this volume of fluid would increase pore fluid pressure within the entire formation by 0.09 MPa (~13 psi). Recent spot measurements of pressure in the Ellenburger confirm that elevated fluid pressures ranging from 1.7 to 4.5 MPa (250–650 psi) above hydrostatic exist in this formation, and this may promote failure on pre-existing faults in the Ellenburger and underlying basement. The analysis demonstrates a clear spatial and temporal correlation between seismic activity and wastewater injection volumes across the basin, with earthquakes generally occurring in the central and eastern half of the basin, where Ellenburger wastewater injection cumulative volumes and estimated pressure increases are highest. The increased seismicity correlates with increased fluid pressure, which is a potential cause for these earthquakes. Based on these results, we hypothesize it is plausible that the cumulative pressure increase across the basin may trigger earthquakes on faults located tens of kilometers or more from injection wells, and this process may have triggered the Irving-Dallas earthquake sequence. We use these results to develop preliminary forecasts for the region concerning where seismicity will likely continue or develop in the future, and assess what additional data are needed to better forecast and constrain seismic hazard.

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1. Introduction

The Bend Arch-Fort Worth Basin in North Texas has experienced a rapid increase in the number of earthquakes beginning in 2008 (Fig. 1). This basin includes the largest metropolitan area in the southern United States–the Dallas-Fort Worth Metroplex. Prior to 2008, no confirmed felt earthquakes had occurred in the basin despite more than 160 years of settlement and more than 40 years of seismic monitoring (Frohlich and Davis, 2002; Frohlich et al., 2011, 2016). Since 2008, however, earthquakes in the Fort Worth Basin have generally increased in number, magnitude, and hence moment release, with the basin experiencing its largest (M4.0) earthquake in 2015 (Fig. 2).

There have been numerous investigations concerning the cause of recent earthquakes in North Texas and most conclude that the injection of oil and gas flowback brine water into deep sedimentary formations is probably responsible for reactivating faults and causing seismicity in the basin (Frohlich et al., 2011, 2016, 2012; Justinic et al., 2013; Gono et al., 2015; Hornbach et al., 2015). All

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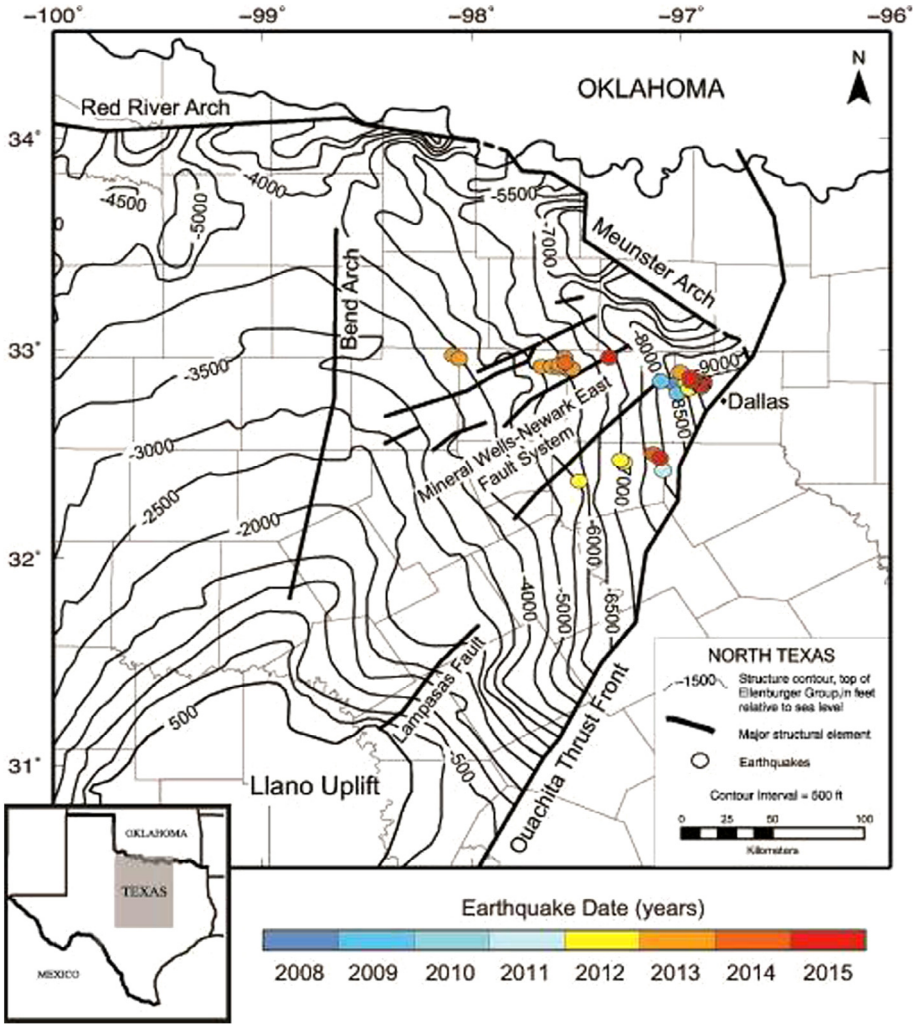

Fig. 1. Map of the Bend-Arch Fort Worth Basin showing earthquake epicenters reported in the USGS ANSS Catalog (location uncertainty of ~10 km). Contours indicate the top of the Ellenburger formation based on Pollastro et al. (2007). The basin depocenter is below the cities of Irving and Dallas in western Dallas County, where a significant increase in seismicity occurred in the past 3 years.

of these investigations focus on discreet relationships between regional wastewater injection sites and earthquakes. An important unanswered question is why some high volume injection sites induce earthquakes while others do not. Fully addressing the induced seismicity hazard requires understanding not only subsurface pressure changes but also the local stress regime. Although the stress regime in the Fort Worth Basin is only marginally constrained, published earthquake focal mechanism across the basin (e.g. Justinic et al., 2013; Hornbach et al., 2015) suggest the maximum principal stress direction extends in a northeast to southwest direction consistent with regional stress studies (e.g. Zoback and Zoback, 1980).

Two of the investigations assessing the cause of earthquakes in the Fort Worth basin (Gono et al., 2015; Hornbach et al., 2015) modelled subsurface permeability, pressure, and structure to estimate pore fluid pressure changes over time. Although both studies concluded regional seismicity is most likely induced by wastewater injection, a limitation of these modeling studies is their inability to fully account for subsurface complexity, and thus to constrain completely how pressures and volumes of injected wastewater influence subsurface stress. Specifically, significant uncertainties concerning fault locations, fault orientations, fault permeability, fluid flow paths, and regional stress regimes often limit the applicability of such modeling investigations. Limitations of these studies, combined with a decade of pressure and injection data made available by the Texas Railroad Commission, motivate us to explore alternative methods for forecasting where future seismicity might occur as wastewater injection continues in the basin.

In the present investigation we apply an alternative statistical approach that avoids the uncertainties associated with detailed 3D fluid flow modeling; we make straightforward statistical comparisons between wastewater injection practices, subsurface pressures, and regional seismicity. Statistical methods comparing seismicity and injection have found a correlative relationship in other large basins, especially in Oklahoma (e.g. Walsh and Zoback, 2015; Weingarten et al., 2015). In the Fort Worth Basin, Frohlich (2012) compared wastewater injection locations with regional seismicity during the two years when the US Earthscope Transportable Array was deployed across the area. Additionally, for 13 of the 28 counties located in the Fort Worth Basin, Gono et al. (2015) produced a nearly basin-scale fluid model noting the relationship between modeled subsurface pressure in the Ellenburger and regional seismicity. While both of these investigations found a spatial association between wastewater injection, subsurface injection pressure, and regional seismicity, neither evaluated the complete publically available pressure/volume data for all wastewater injection wells in the Ellenburger for the entire ~ 10 year period when seismicity has increased significantly (Fig. 2).

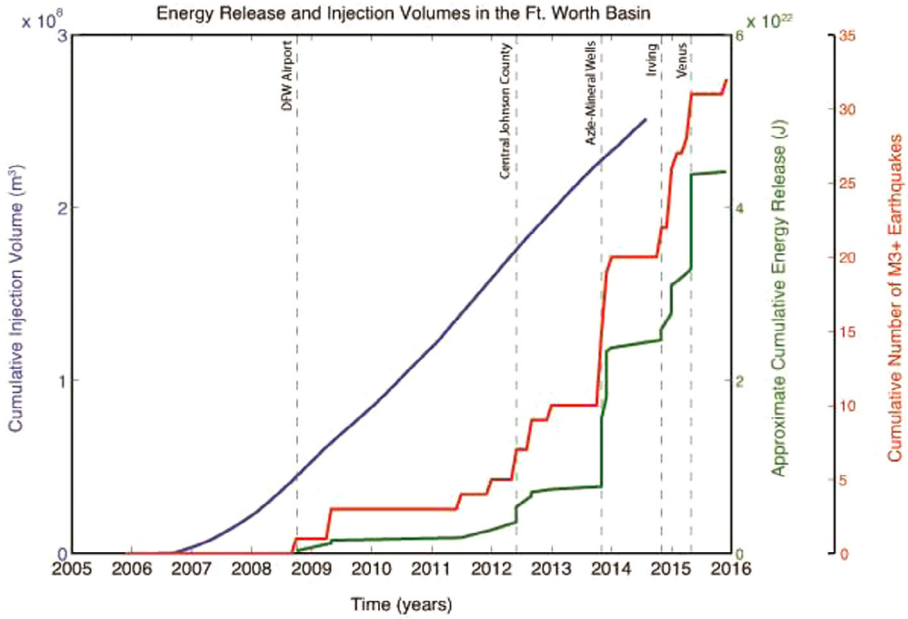

Fig. 2. Cumulative injection volumes, number of earthquakes at magnitude 3 and greater, and scalar moment which we use as a proxy for seismic energy release in the Ft. Worth Basin since 2005. Injection data were taken from the Texas Railroad Commission and earthquakes are M3.0 and above from the USGS Catalog. The energy is calculated by multiplying the scalar moment by a constant using the approach of Hanks and Kanamori (1979). Dashed lines represent the beginning of a sequence containing two or more magnitude 3 earthquakes.

For all 28 counties within the Fort Worth Basin, the present investigation compiles and analyzes earthquake locations for all USGS-reported earthquakes of magnitude 3 or greater, as well as more than 24,000 monthly injection volume and pressure measurements for the years 2005–2014 using data available online and archived by the Texas Railroad Commission. We use these data to assess the relationship between wastewater injection, time, pressure, and seismicity in North Texas over a ~10 year period and to generate forecasts for seismicity in the region.

2. Geologic background

2.1. Tectonic setting

The Bend Arch-Fort Worth Basin is an Ordovician age (greater than400 Ma) sedimentary basin covering an area of ~63,000 km^2 in North Central Texas. The basin is an asymmetric feature bounded by the Ouachita thrust and fold belt to the east, the Muenster Arch and Amarillo Uplift to the north, the Bend Arch structural fold belt to the west, and the Llano uplift to the south (Fig. 1) (e.g. Montgomery et al., 2005; Pollastro et al., 2007). Sediments in the basin dip east-northeast with the deepest part of the basin located below the city of Dallas at a depth of ~3700 m below sea level (Fig. 1) (Core Laboratories Inc, 1972; Pollastro et al., 2007). Although only a few large faults are mapped in the basin, nearly all follow a similar strike that extends along a southwest-northeast trend (e.g. Budnik et al., 1990; Ewing, 1991), consistent with regional seismic reflection studies (e.g. Sullivan et al., 2006) and the estimated current maximum horizontal stress direction (e.g. Zoback and Zoback, 1980; Huffman, 2003; Heidbach et al., 2008). Regional fault studies indicate the basin has not experienced widespread or significant tectonic activity for the past ~300 Ma (e.g. Muehlberger, 1965; Rozendal and Erskine, 1971; Huffman, 2003). Thus considering these observations, the occurrence of frequent felt earthquakes since 2008 within the basin is highly anomalous (Sullivan et al., 2006; McDonnell et al., 2007; Frohlich, 2012; Hornbach et al., 2015).

2.2. Recent seismicity

In the Fort Worth Basin since 2008, the cumulative number of earthquakes having magnitudes of 3 or more increases roughly exponentially, with discreet increases associated with individual earthquake sequences (Fig. 2). Many North Texas earthquake sequences do not follow typical mainshock-aftershock patterns but consist of swarms of small earthquakes. These include sequences in eastern Tarrant County near the Dallas-Fort Worth (DFW) airport beginning in 2008 (Frohlich et al., 2011), in Johnson County near Cleburne beginning 2009 (Justinic et al., 2013), in central Johnson County in 2012 and near Venus in eastern Johnson County in 2011(Frohlich, 2012) and again in 2015, in Dallas and Irving beginning in 2012 and continuing intermittently up to the present, and in Parker and Palo Pinto Counties near Azle and Mineral Wells beginning in 2013 and continuing intermittently up to the present (e.g. Hornbach et al., 2015). All these earthquakes occur either within the deepest and oldest sedimentary formations of the basin (primarily the Ellenburger), or in the basement Precambrian granite immediately underlying, and likely in direct pressure communication with, the Ellenburger (Frohlich et al., 2011; Justinic et al., 2013; Hornbach et al., 2015). The published investigations of all these sequences concluded that it was plausible or probable that they were induced by increased subsurface fluid pressures associated with the injection of wastewater. These results are also consistent with numerous recent studies that suggests fluid injection into formations directly above basement faults, such as the Ellenburger, increases the likelihood of earthquake activity (e.g. Frohlich, 2012; Ellsworth, 2013; National Research Council, 2013; McGarr, 2014; Walsh and Zoback, 2015; Rubinstein and Mahani, 2015).

2.3. The source of wastewater injected into the Ellenburger

The wastewater injected into the Fort Worth Basin is a byproduct of gas production mostly from the Barnett Shale (Montgomery et al., 2005; Bowker, 2007; Jarvie et al., 2007), an organic rich but geologically tight formation. Although the Barnett

has high hydrocarbon production potential, its low permeability (typically less than 10^{-18} m^2) makes it difficult to exploit using conventional methods. The Barnett Shale unconformably overlies the Viola limestone and Ellenburger dolomite/limestone formations and underlies the Marble Falls Limestone formation (Fig. 3). The low permeability of the Barnett forms a natural seal, separating the Marble Falls and Ellenburger limestone aquifers from each other. Gas production for the Barnett Shale requires hydraulic fracturing, and a byproduct of this practice is wastewater (also called brine) that usually contains high concentrations of total dissolved solids. This brine is produced as a result of both flowback from hydraulic fracturing and from extraction of naturally occurring formation water. Brine produced in typical oil and gas fields can have total dissolved solids in excess of 250,000 ppm (Gregory et al., 2011), ~10x saltier than seawater. To avoid environmental surface damage, oil and gas companies typically reinject brines into deep, isolated saltwater formations that are not in communication with shallower, fresh water aquifers.

We estimate that a majority of the water being injected into the Ellenburger is flowback water associated with the hydraulic fracturing process. According to the Texas Railroad Commission website, at least 15,000 unconventional wells have been drilled in the Barnett Shale. The average well in the Barnett shale that is hydraulically fractured uses between 11,000 and 19,000 m^3 (69,000–119,000 bbls) of water (Nicot et al., 2014). If injected water is ultimately recovered from each well during production, then the total amount of flowback water from Barnett production ranges from 175 to 285 million m^3 (1.1–1.8 billion bbls). As we will show, this amount is equivalent to ~65–106% of the total volume of water injected into the Ellenburger since 2005. Thus, the amount of water used to hydraulically fracture the Barnett from 2006 to 2014 is consistent to first-order with the amount of wastewater injected into the Ellenburger during that same time.

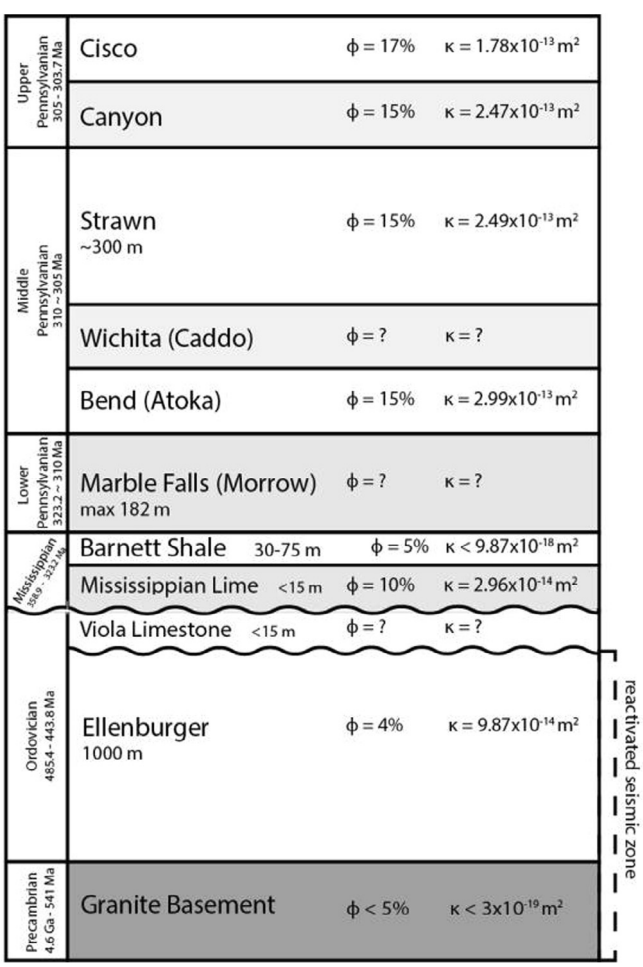

Fig. 3. The main formations used for wastewater injection in the Fort Worth Basin with respective porosities (ϕ) and permeabilities (κ). Figure shows approximate relatively thicknesses in the center of the basin. (Core Laboratories Inc. 1972; Gale et al., 2007; Montgomery et al., 2005; Loucks et al., 2009; Pollastro et al., 2003; Brace et al., 1968; Skoczylas and Henry, 1995; Geraud, 1994).

2.4. The fate of oilfield wastewater

Currently, oil and gas companies reinject wastewater into several different formations in the Fort Worth Basin. These formations, from shallowest to deepest, include (but are not limited to) the Cisco, Canyon, Strawn, Caddo, Atokan, Marble Falls, and the Ellenburger formations (Fig. 3). The age of the youngest formation outcropping at the surface of the basin is no younger than 65 Ma. The Ellenburger is the oldest (age >450 Ma), deepest, and thickest: it is a massive, ~1 km thick karsted dolomite/limestone formation that extends across the entire basin (e.g. Core Laboratories Inc, 1972; Pollastro et al., 2007; see also Fig. 1). The Ellenburger overlies basement granite wash and unconformably underlies the Viola Limestone and Barnett Shale (Fig. 3) (e.g. Montgomery et al., 2005; McDonnell et al., 2007). The top of the Ellenburger formation is shallowest in the west, averaging a depth of ~1000 m near the Bend Arch, but steadily deepens to the east, toward the formation depocenter and lowest potential drainage point at a depth of ~2800 m below sea level under the cities of Irving and Dallas (Core Laboratories Inc, 1972) (Fig. 1).

The Ellenburger is the single largest aquifer in Texas, and it contains waters ranging in salinity from fresh at its shallow locations to hyper saline (150,000 ppm, ~5x seawater) at greater depths (Core Laboratories Inc, 1972). Despite its significant volume, some physical properties of the Ellenburger are not ideal for wastewater storage: it has generally lower porosity (Φ) and permeability (κ) than other shallower Fort Worth Basin aquifers (Fig. 3), and although thick and therefore voluminous, regional seismic surveys indicate the Ellenburger is at many locations in direct contact with basement faults. Some of these basement faults extend through the Ellenburger and into the Barnett, providing connectivity between the units (e.g. Khatiwada et al., 2013). The Ellenburger formation porosity ranges between 2% and 12% but averages only 4% (Core Laboratories Inc, 1972). Regional studies combined with pressure fall-off tests indicate the formation has moderate permeability (0.1–500 mD) and, since it directly overlies the basement, fluids in the Ellenburger formation are likely in direct communication with basement faults at many sites.

The Ellenburger is largely a non-productive formation and, unlike many other formations in the basin where oil and gas have been produced extensively, has experienced only very limited fluid extraction for hydrocarbon production in the Fort Worth Basin. Some fluids have been intentionally extracted from the Ellenburger on the far western edge of the basin on top of the Bend Arch anticline or outside the basin entirely (e.g. Autry, 1940; Bradfield, 1964; Loucks and Anderson, 1985) and in limited instances, hydraulic fracturing has caused fracturing into the Ellenburger (Pollastro et al., 2007). For the vast majority of hydraulic fractures within the Barnett shale, however, there is little or no evidence of significant water flowback from the Ellenburger, with annual water production (G-1 and G-10) test reports provided by the Texas Railroad Commission typically indicating no significant flowback occurring within a year of the onset of production. Previous studies also suggest significantly more brine is injected into the Ellenburger than is produced from the Ellenburger in a particular region (e.g. Hornbach et al., 2015). Thus, while the Ellenburger is one of the largest brine sinks in the region, it has experienced only

Table 1
Total Ellenburger and total injection volumes by county, compiled from all available data accessible through the Texas RRC website, from December 2005 to November 2015.

County	County Area in Fort Worth Basin (sq.km)	Ellenburger - Total Volume (cubic m)	Total Volume (cubic m) *TRRC reports date back no further than 2005*	Ellenburger Volume/ Total Volume	Ellenburger - Total Volume per County Area (cubic m per sq. km)	Ellenburger - Total Volume per County Area (meters)	Total Volume per County Area (cubic m per sq.km) *TRRC reports date back no further than 2005*	Ellenburger Volume per Area/Total Volume per Area	# Inj Permits	# Inj Permits Ellenburger Only	# Inj Permits with H-10 data Ellenburger Only	# Inj Permits w/H-10 data in Ellenburger/ # Inj Permits
Archer	2357	43,147	2,17,31,269	0.199%	18	0.000018306	9220	0.199%	2716	5	2	0%
Bosque	2561	0	0	–	0	0.000000000	0	–	2	2	0	–
Brown	2445	0	16,49,521	0.000%	0	0.000000000	675	0.000%	540	0	0	0%
Burnet	2577	0	0	–	0	0.000000000	0	–	0	0	0	–
Clay	2683	1,35,601	96,30,627	1.408%	51	0.000050535	3589	1.408%	981	9	2	0%
Comanche	2429	0	34,031	0.000%	0	0.000000000	14	0.000%	43	0	0	0%
Coryell	2562	0	0	–	0	0.000000000	0	–	3	0	0	–
Dallas	801	0	0	–	0	0.000000000	0	–	0	0	0	–
Denton	1541	63,03,866	64,45,431	97.804%	4090	0.004089793	4182	97.804%	40	5	3	8%
Eastland	2398	8,81,730	1,80,92,628	4.873%	368	0.000367694	7545	4.873%	831	7	4	0%
Erath	2813	11,65,433	14,05,908	82.895%	414	0.000414302	500	82.895%	36	13	6	17%
Hamilton	2165	0	26,424	0.000%	0	0.000000000	12	0.000%	9	2	0	0%
Hill	1023	30,77,541	30,79,829	99.926%	3008	0.003007999	3010	99.926%	10	3	3	30%
Hood	1093	1,93,55,818	2,19,76,196	88.076%	17,709	0.017708891	20,106	88.076%	31	20	13	42%
Jack	2375	1,04,86,081	2,56,86,745	40.823%	4415	0.004415192	10,815	40.823%	1129	41	25	2%
Johnson	1888	11,22,01,133	11,38,80,566	98.525%	59,429	0.059428566	60,318	98.525%	39	39	27	69%
Lampasas	1844	0	0	–	0	0.000000000	0	–	0	0	0	–
Mills	1937	0	0	–	0	0.000000000	0	–	0	0	0	–
Montague	2107	1,32,58,069	6,83,20,137	19.406%	6293	0.006293035	32,429	19.406%	947	17	8	1%
Palo Pinto	2468	71,14,911	1,27,58,373	55.767%	2883	0.002882865	5170	55.767%	378	33	15	4%
Parker	2341	3,54,16,831	3,77,59,218	93.797%	15,129	0.015128933	16,130	93.797%	65	19	16	25%
San Saba	2937	0	0	–	0	0.000000000	0	–	0	0	0	–
Somervell	484	1,00,52,570	98,43,163	102.127%	20,770	0.020769772	20,337	102.127%	6	6	5	83%
Stephens	2318	14,93,560	30,66,97,456	0.487%	644	0.000644331	1,32,311	0.487%	1621	11	9	1%
Tarrant	2238	3,10,02,071	3,60,51,412	85.994%	13,853	0.013852579	16,109	85.994%	14	13	9	64%
Wichita	1462	46,338	10,25,40,669	0.045%	32	0.000031685	70,116	0.045%	4931	4	2	0%
Wise	2344	1,68,39,841	3,32,19,943	50.692%	7184	0.007184232	14,172	50.692%	287	18	8	3%
Young	2388	9,39,788	2,54,35,266	3.695%	394	0.000393546	10,651	3.695%	1938	23	10	1%
TOTAL	58,580	26,98,14,329	85,62,64,812	32%	1,56,682	0.15668226	4,37,410	36%	16,597	290	167	1%

limited fluid removal that might reduce formation pressures, particularly near the depocenter of the Fort Worth Basin.

3. Methodology

3.1. Data compilation

Wastewater injection/pressure data for Class II injection wells in Texas are collected and archived by the Texas Railroad Commission and publically available online. Since 2006, monthly pressure and injection volumes for each well site have been compiled annually at the end of each fiscal year on H-10 forms and provided publically online by the Texas Railroad Commission. Of a total of 290 verified disposal well permits for the Ellenburger in the Fort Worth Basin, we found 167 wells with H-10 reports, providing detailed injection volumes and well-head pressures from as early as late 2005 through September 2014 (Texas Railroad Commission, last accessed December 2015). To determine which formation wells inject into, we analyzed injection disposal permits. In instances where the injection formation is not specified explicitly, we identified it from the injection depth interval combined with regional subsurface formation tops (e.g. Pollastro et al., 2007). We compile and summed monthly Ellenburger injection volumes and pressures at all locations throughout the Bend-Arch Fort Worth Basin, spanning a total of 28 counties (Table 1).

We analyzed broad-scale pressure and injection trends by estimating (1) the volume injected per unit area, by county, over time, (2) the mean change in formation compressibility (see below), (3) the relative number and location of Ellenburger injectors, by volume, compared to the total number of injectors and the total injection volume in the basin, and (4) the spatial and temporal relationship between Ellenburger injection volumes, pressures/volume ratios, and regional seismicity. H-10 reports indicate how often pressure measurements were made at each well site. To ensure temporal consistency for injection pressure measurements, we only analyze pressures at wells where H-10 reports indicate daily pressure measurements were made to estimate an average monthly injection pressure. The full analysis, incorporating more than ~24,000 monthly data points, is used to make basic observations regarding wastewater injection, injection pressure, and seismicity in and below the Ellenburger.

3.2. Calculation of pressure and apparent compressibility

Assessing changes in relative formation compressibility provides important insight into subsurface fluid pressures changes, and in particular, allows us to identify locations where fluid pressure increases with time, promoting seismicity. For a given geological formation, if fluids are added faster than fluids leave, the formation pressure increases, and will continue to increase until there is failure via either plastic deformation, hydraulic fracture, or fault slip. It is well established that increasing fluid pressures increases the risk of seismicity and rock fracturing (e.g. Terzaghi, 1943; McLatchie et al., 1958; Zoback and Hickman, 1982), and that faulting may help relieve pressures in some areas, while increase stress in other areas (e.g. Stein, 1999). For each injector site where daily pressure measurements were made, we calculate changes over time in the formation as apparent compressibility, β

$$\beta = \frac{1}{V_e}\frac{\mathrm{dV}}{\mathrm{dP}} \tag{1}$$

here dV is the change in monthly volume injected at each injector site, dP is the change in mean monthly injector pressure at each injector site, and V_e is the approximate volume of the Ellenburger formation, which we estimate from isopach maps to be ~63,000 km^3 (Core Laboratories Inc, 1972). β represents an apparent compressibility and not a true compressibility because the calculation is local and uses pressures measured at the well head, not within the formation. Although this approach does not provide the true compressibility, the value calculated provides insight into whether compressibility, and therefore subsurface pressure, is increasing, decreasing, or holding steady with time at each injection site. One way to visualize or characterize what we are assessing is revealed in the $\frac{\mathrm{dV}}{\mathrm{dP}}$ term of the equation. If more pressure is required to inject the same volume of wastewater in a given time, then the pressure in the formation near the well site is increasing and the compressibility of the formation is decreasing.

We can calculate the average, basin-wide pressure change in the Ellenburger formation by recasting the compressibility equation in terms of a change in pressure, dP:

$$dP = \frac{1}{V_f}\frac{\mathrm{dV}}{\beta_f} \tag{2}$$

here dP is the average change in fluid pressure in the pores in the Ellenburger formation; V_f, the pore fluid volume for the Ellenburger for the basin, is calculated assuming an average porosity of 4% (Core Laboratories Inc, 1972) and a formation volume of 63,000 km^3, yielding an average pore volume of 2520 km^3; β_f, the average formation compressibility, estimated directly by studies commissioned by the Texas Railroad Commission for the Ellenburger, is 1.2×10^{-3} MPa^{-1} (http://www.rrc.state.tx.us/about-us/resource-center/research/special-studies/johnson-county/); and dV is the fluid volume injected as wastewater into the Ellenburger starting in 2006 and totaling 270 million m^3 through September, 2014. Using these data, we calculate an average increase in fluid pressure throughout the entire basin of 0.09 ± 0.02 MPa (~13 ± 3 psi), where uncertainties here are attributed only to uncertainties in basin formation area and volume (Pollastro et al., 2007; Core Laboratories Inc, 1972).

4. Results and analysis

4.1. Ellenburger injection volumes

As noted above, since 2006 approximately 270 million cubic meters (1.7 billion barrels) of wastewater have been injected into the Ellenburger formation in the basin (Fig. 2). The total volume of injected fluid increases between 2006 and 2009 and has since held relatively steady at approximately 35 million m^3 per year (Figs. 4A and 4B). Between 2006 and 2008, monthly volumes increased by more than a factor of 10, averaging less than 160 thousand m^3 a month in 2006 but more than 2 million m^3 per month by the end of 2008, with injection volume rates sustained near these values since 2009. Peak monthly injection of 3.5 million m^3 per month occurred at the end of 2011 and early 2012, and since then, injection volumes have sustained high values, typically exceeding 2.5 million m^3 per month through 2014 (see Table 2).

Geographically, the most significant injection occurs in the central-eastern half of the basin, near and surrounding the basin depocenter (Figs. 1 and 5). Ten of the 28 counties within the Bend-Arch Fort Worth Basin had no injection into the Ellenburger (Table 1). There is wide variability among the 18 counties with injection reports into the Ellenburger. The counties with the five highest Ellenburger injection volumes per unit area are, in decreasing order, Johnson, Sommervell, Hood, Parker and Tarrant counties, all in the central eastern portion of the Basin near the Dallas-Fort Worth-Arlington Metroplex. These counties, which represent only 12.75% of the surface area of the basin, accommodated more than 81% of all wastewater injected into the Ellenburger formation. In addition, the highest volume individual injectors are in these

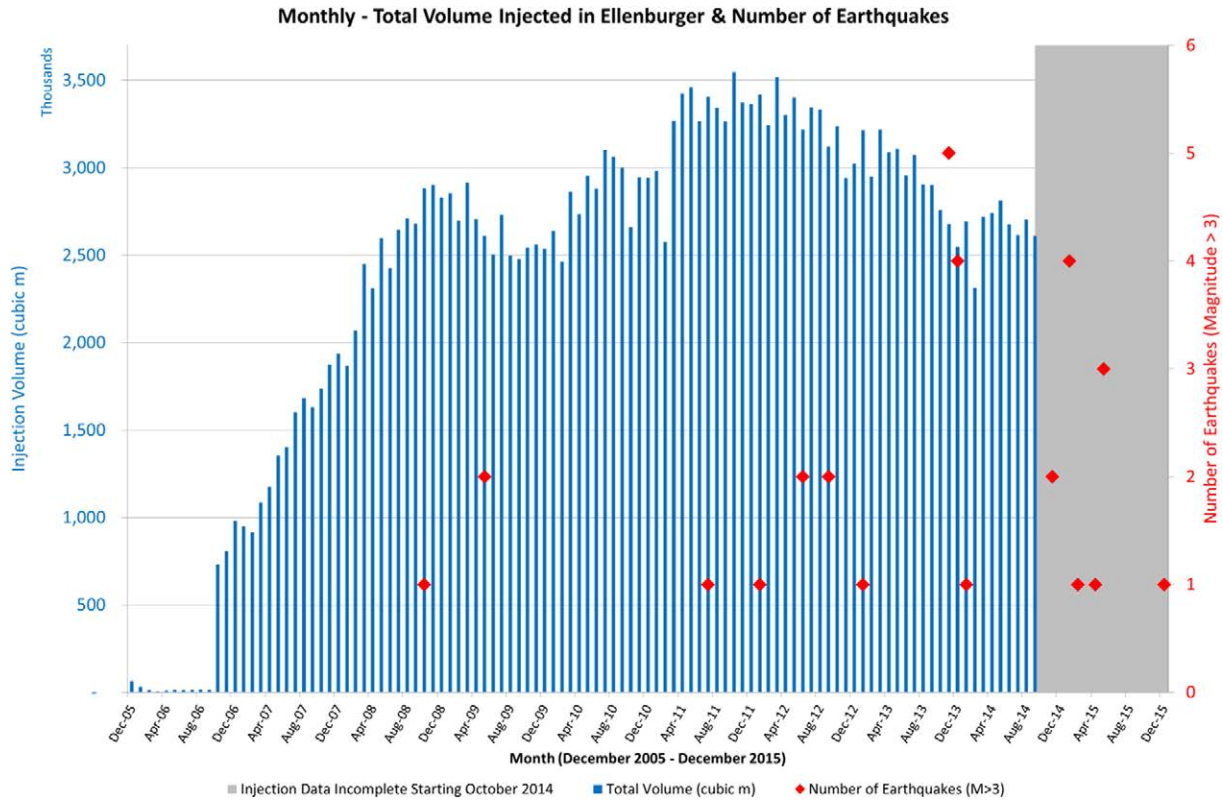

Fig. 4A. Earthquakes with magnitudes greater than 3 (red diamonds) and monthly injection rates into the Ellenburger in the Fort Worth Basin (blue bars) from December 2005 to October 2014. After October 2014 injection data is incomplete (gray box). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

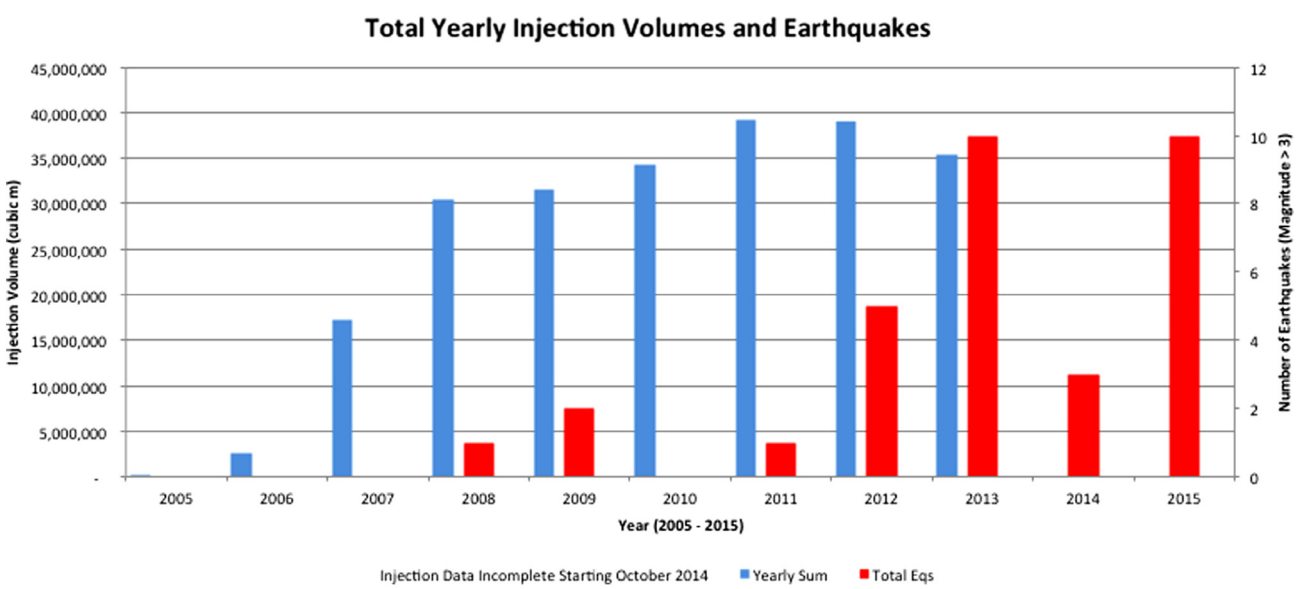

Fig. 4B. Bar chart showing the total yearly injection volume into the Ellenburger throughout the entire basin (blue) and the total number of earthquakes per year of magnitudes greater than 3.0 (red). Injection data is incomplete starting October 2014, so complete annual data are unavailable for 2014. The most rapid increases in injection volume occur from 2005 to 2008, and continues to steadily increase by 4–15% per year until 2011. From 2011 to 2013 yearly injection volumes decrease by 9–15% per year. A phase shift of two years gives the highest correlation coefficient (0.75) between annual seismicity and annual Ellenburger injection volume, however the analysis is clearly limited by available seismic data, as only earthquakes having magnitude 3.0 or greater are used. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

counties, with the largest (in Tarrant County) injecting approximately 8 million m^3 of brine into the Ellenburger between 2006 and 2014 (see Table 3). Of the 10 largest injectors, all are in three counties: Johnson (6), Tarrant (2), and Parker (2) (Table 3). These 10 wells represent only 6% of all wells in the basin injecting into the Ellenburger, but they accepted 25% of all Ellenburger

Table 2
Wastewater injection into the Ellenburger by year showing percent change and USGS reported seismicity for Magnitude 3 earthquakes by year. Annual injection volumes into the Ellenburger are based on all downloadable H-10 reports made publicly available on the Texas Railroad Commission web site.

Year	Total Injection Volume (cubic m)	% Change in Injection Volume	Total Eqs (M>3)
2005	62,627	–	0
2006	2,638,753.87	+4113%	0
2007	17,332,805.14	+557%	0
2008	30,363,307.59	+75%	1
2009	31,629,742.23	+4%	2
2010	34,244,309.21	+8%	0
2011	39,262,619.16	+15%	1
2012	39,090,310.47	-0.04%	5
2013	35,391,447.41	-9%	10
2014	–	–	3
2015	–	–	10

wastewater. If we interpolate injection volume for wells across the basin, we observe the highest injection volumes per unit area below the central and eastern portion of the basin (Fig. 6).

Temporal analysis of injection volume per unit area, aggregated by county, indicates the central-eastern half of basin experienced the highest cumulative injection volumes, and that only recently (2010–2014) has injection volume increased significantly to the north and west (Fig. 7). High injection volumes began in Johnson, Sommervell, Tarrant, Parker, and Hood counties in 2005–2008, and high annual injection volumes have since been generally sustained. From 2008 to 2010, Palo Pinto, Jack, Wise, and Denton Counties experienced significant increases in annual injection volume. More recently (from 2010 to 2014), these injection volumes increased in Wise and Montague Counties.

Although the Texas Railroad Commission does not provide total injection rates for individual formations, it does provide the total

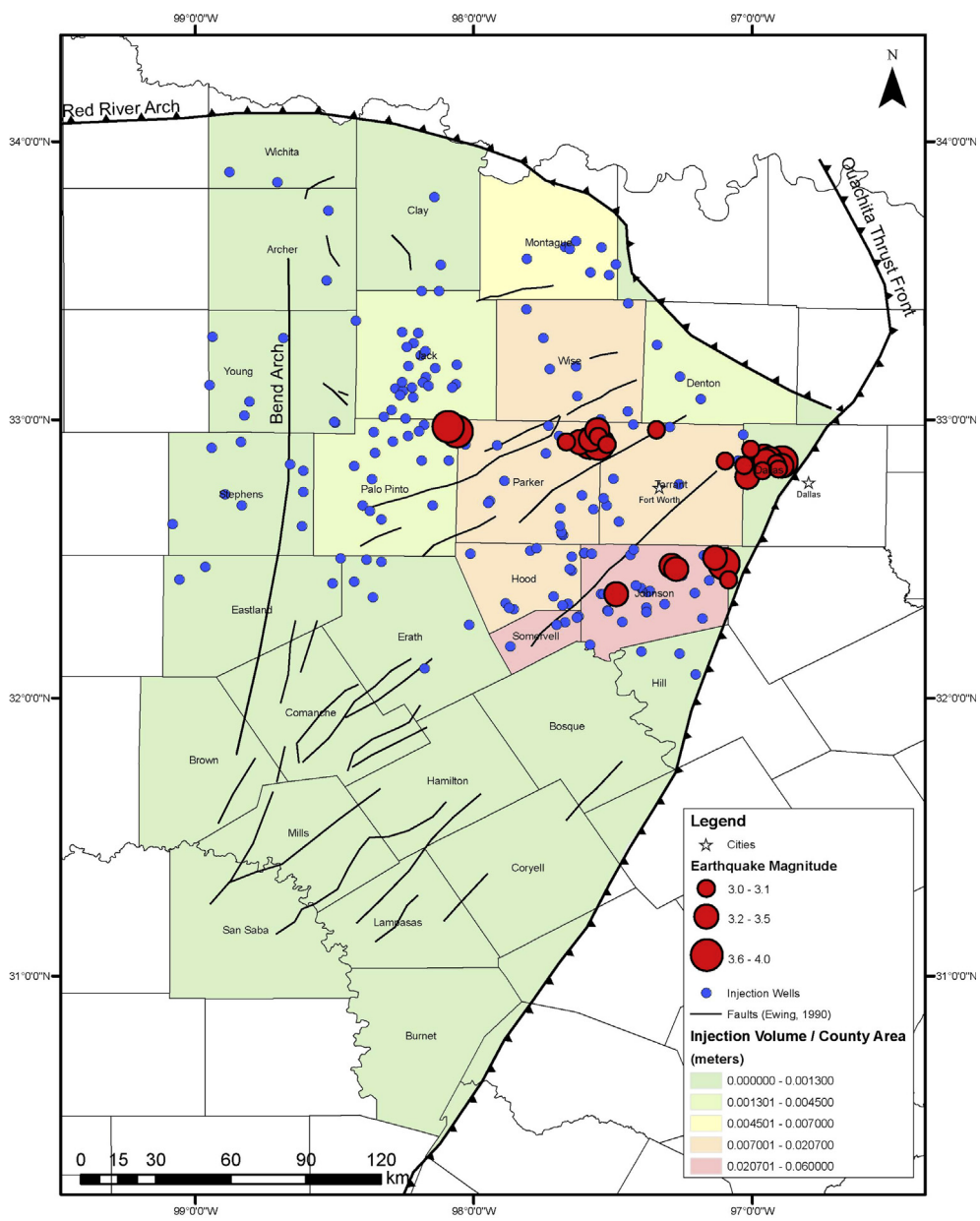

Fig. 5. The location of earthquakes (red) injection wells (blue) and injection volume per unit area, aggregated by county (colored counties). Earthquakes generally occur within or adjacent to counties where the injection volumes are highest. Our analysis of formation compressibility and subsurface pressures indicates the same areas where injection volumes are highest also experience the most significant subsurface pressure increases with time. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 3
Top 20 Ellenburger injectors by volume in the Fort Worth Basin from 2005 to 2014. Magnitude 3 or greater earthquakes have occurred within 10 km of 46% of the top 20 injectors, and 50% of the top 10 injectors. For the remaining 147 smaller volume injector wells in the basin, only 6% have experienced earthquakes within 10 km of their injection sites.

County	Total Volume (bbls)	Total Volume (cubic m)	No. EQs (M>3) within 10 km	Date of EQ
Tarrant	50,112,720	79,67,286.05	1	17-12-2015
Johnson	49,559,591	7,879,345.56	0	
Tarrant	47,269,368	7,515,229.19	0	
Parker	45,263,623	7,196,341.21	0	
Johnson	44,255,812	7,036,112.06	2	11/30/14, 5/7/15
Johnson	43,863,439	6,973,729.74	1	18-01-2012
Johnson	40,506,255	6,439,980.12	1	18-01-2012
Johnson	37,360,019	5,939,768.55	0	
Johnson	36,743,655	5,841,774.50	2	6–24-12, 6-15-12
Parker	35,559,264	5,653,471.37	0	
Johnson	34,468,836	5,480,107.17	0	
Johnson	33,551,658	5,334,287.52	3	5/7/15, 11/30/14, 7/17/11
Denton	33,459,656	5,319,660.37	0	
Johnson	32,680,831	5,195,837.08	0	
Tarrant	32,244,615	5,126,484.28	0	
Johnson	31,364,464	4,986,551.45	0	
Johnson	31,221,778	4,963,866.19	0	
Johnson	31,188,357	4,958,552.67	2	6/24/12, 6/15/12
Parker	29,689,424	4,720,241.36	2	11/25/13, 11/9/13
Johnson	29,076,663	4,622,820.14	2	11/30/14, 5/7/15

monthly wastewater volumes injected into all formations (not just the Ellenburger). The total volume injected for the entire basin 2006–2014 is 795 million m^3 (~5 billion barrels). Our analysis therefore indicates that approximately 1/3 of all wastewater injected into the Bend-Arch Fort Worth Basin is injected into the Ellenburger.

4.2. Comparison of Ellenburger injection volumes with basin seismicity

When earthquakes occur they generally have been in the counties with the highest injection volumes (Parker, Johnson or Tarrant Counties), or in counties immediately adjacent to these counties (Dallas, Ellis, and Palo Pinto counties). For example, Johnson, Tarrant, and Parker Counties, the three counties where wastewater disposal rates are highest, have also experienced a disproportionately large number of earthquakes, with 47% of all USGS-reported earthquakes greater than M3 occurring in these counties. Since 2005 the total volume of wastewater injected into the Ellenburger in these counties exceeds 178,600,000 m^3; this is ~67% of all wastewater injected into the Ellenburger in the Fort Worth Basin. Thus, Counties that have experienced the highest injection rates since 2005 are also the counties with high earthquake concentrations. Although no wastewater injection occurs in Dallas and Ellis counties, both counties are immediately adjacent to two counties with very high wastewater injection rates (Johnson and Tarrant). Additionally, subsurface structural maps based on well logs show that in the Fort Worth basin the Ellenburger dips northward and eastward toward the Ouachita Front, reaching its deepest depth and largest thickness beneath Dallas and Ellis counties (Core Laboratories Inc, 1972; Fig. 1). Since the Ellenburger is a permeable formation, it is likely that heavier injection fluids will naturally gravitate eastward towards Dallas and Ellis counties, potentially increasing fluid pressure in this region.

Earthquakes also occur disproportionately near large injection wells, just as previous studies suggest (e.g. Frohlich, 2012). For example, of the 10 largest injection wells by volume in the basin, 50% have had a M3 or greater earthquake occur within 10 km (Table 3). Similarly, of the 20 largest injector wells by volume in the county, 46% have had a M3 or greater earthquake occur within 10 km. Indeed, the M 3.0 earthquake near Haslet, Texas, on December 17, 2015 represents the most recent example of this pheonomenon: the Haslet earthquake epicenter was within ~1 km from the single largest injection well (by cumulative volume) in the entire basin. In contrast, if we exclude the top 20 injector wells by volume, only 6% of the remaining 147 injector wells have had a M3 or greater earthquake occur within 10 km. Thus, for areas within 10 km of a a large injector well, the earthquake probability appears significantly (nearly a factor of ten) greater. This result is consistent with previous investigations in the Fort Worth Basin noting spatial and temporal relationships between seismicity and wastewater injection (e.g. Frohlich, 2012).

4.3. Changes in Ellenburger compressibility with time

We calculated the monthly apparent compressibility for 84 wells where pressure measurements were made consistently on a daily basis. Of these, 43 (51%) showed evidence for reduced compressibility (increased formation pressure) with time, 21 (24%) showed evidence for increased compressibility (reduced formation pressure) with time, and 20 (24%) show no significant change in compressibility (no clear pressure change) with time. It is important to recognize that apparent reduction in compressibility (and increase in pressure) may simply be the result of increased friction as more fluids are injected into the well with time. We note however that 39 of the 43 wells (91%) with reduced compressibility have monthly injection volumes that remain either *constant* or systematically *decrease* with time while injection pressure increased. This implies that for at least 39 wells, reduced compressibility is not due to increased injection rates and that other factors must be involved. Increased compressibility (reductions in pressure) that we observe in 24% of the wells could be caused by fluid loss in the formation near a particular well due to natural fluid migration, unintentional removal by adjacent oil and gas production, or by fault reactivation that generates more accommodation space for fluids via increased fracture porosity. Currently, there is no significant oil and gas production in the Ellenburger in the central part of the basin. It is therefore perhaps more likely that pressure reductions are caused by natural fluid migration out of the formation. The analysis thus indicates that a majority of wells show an apparent reduced compressibility over time. Counties with the most wells showing reduced compressibility are Parker and Jack counties (6 wells each, 14% of the total), Johnson, Erath, and Hood counties (5 wells each, 12% of the total), followed by Palo Pinto (3 wells), Somervell (2 wells), and Tarrant county (2 wells). These counties are all located in or near areas of high seismicity (Fig. 5). These results therefore demonstrate that there is more than a simple correlation in time and space between high injection volumes and recent seismicity—the injection also provides a mechanism for triggering earthquake activity. Specifically, reduced formation compressibility and increased subsurface pressures below these well sites provide a clear and plausible cause for recent earthquakes: increased subsurface fluid pressures resulting from wastewater injection that is coincident in time and space with regional seismicity provide a simple, direct, observable, and easily explainable mechanism for triggering these seismic events.

4.4. Estimating the average change in Ellenburger formation pressure

For the entire Ellenburger formation, we calculate an average pressure change dP of 0.09 MPa (13 psi) attributable to wastewater injection totaling 270 million m^3 between 2006 and September 2014 (see methods section above). This value is consistent with pressures typically associated with seismic triggering (Reasenberg and Simpson, 1992; Stein, 1999). Our calculation

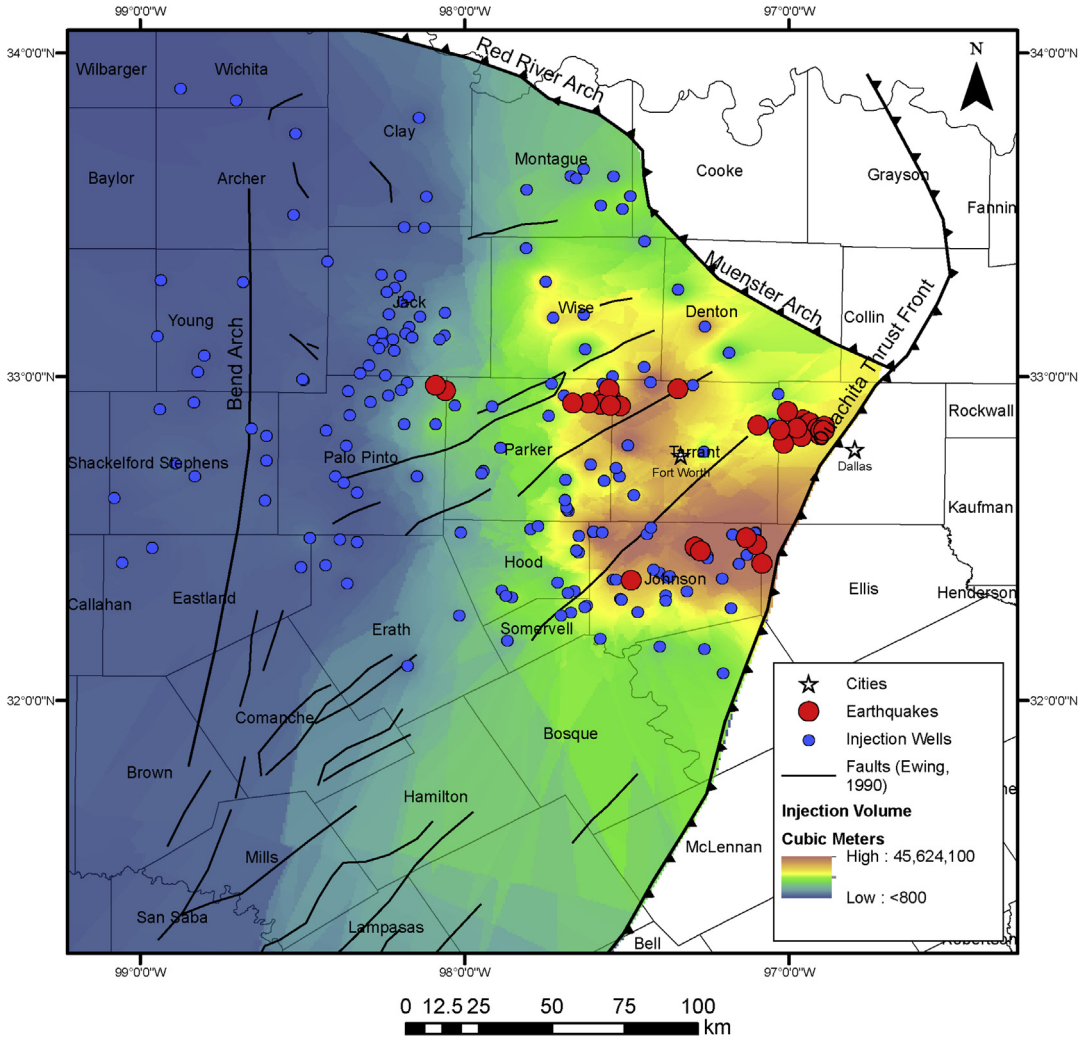

Fig. 6. Map showing an interpolated surface grid of injection volumes per unit area for Ellenburger wells, calculated using the inverse distance weighting (IDW) deterministic method. The interpolation uses the total injection volume of all 167 wells injecting into the Ellenburger formation. The interpolation consists of ~100,000 cells each with an area 817 × 817 m^2. Areas are assigned volumes calculated by a weighted average of the known volumes of the injection wells. Using the weighting approach, approximately 50% of the injected volume is accounted for within 25% of the distance to the next nearest well. The highest injection volumes are generally concentrated in the same regions where we see clusters of earthquakes. Additionally, the Dallas County earthquake sequence lies just southeast and down dip of the high injection volumes in Johnson county. Detailed fault maps will ultimately provide better constraints on how fluids might flow through the basin.

assumes uniform characteristics for the entire Ellenburger, when in fact there is undoubtedly significant heterogeneity (e.g. Core Laboratories Inc, 1972; Loucks et al., 2009). As a result, areas where the reservoir is confined and isolated from regions where injection occurs may have lower fluid pressure, at the expense of areas where wells inject into confined reservoirs that may have significantly higher pressure. For example, if fluids were confined by county, the highest pressure increases would generally occur in counties with the highest injection volumes per unit area (Fig. 8).

Compressibility will be higher (and pressures lower) if gas is present in the Ellenburger formation; however, it is unlikely that much free gas is present in the formation, particularly in the deepest part of the basin. Four lines of evidence support this conclusion. First, there is no significant oil or gas production from the Ellenburger in the basin. Second, the pressures at depths where the Ellenburger exists are not conducive to free gas, as natural gas is significantly more soluble at high pressure and is more dependent on pressure than temperature changes. This suggests that the lowest compressibilities (and the highest pressures) will preferentially occur in the deepest part of the basin, where pressure is highest, methane is more soluble, and the least amount of gas is present.

Third, if significant gas were present, the estimate of 0.09 MPa would be an over-prediction of subsurface pressure. To date, however, all measured pressures in the Ellenburger (provided by shut-in pressure tests) indicate excess fluid pressures higher than 0.09 MPa. For example, recent studies conducted by the Texas Railroad Commission to address the potential cause of recent seismicity in Johnson County, near Venus, Texas, indicate fluid pressures above hydrostatic in all wells tested across the region, with values ranging between 1.7 and 4.5 MPa (250–650 psi) above hydrostatic (http://www.rrc.state.tx.us/about-us/resource-center/research/special-studies/johnson-county/). Similarly, shut-in pressure measurements made at a well in Parker County near the Azle/Reno earthquake sequence also show pressures above hydrostatic (Hornbach et al., 2015). Fourth, it should be noted that the compressibility value used in the calculation is provided directly by engineers assessing subsurface pressures in the Ellenburger, and therefore, if accurate, should properly account for any free gas in the pore fluid. The Ellenburger pressure estimate presented here indicates elevated fluid pressures, just as spot measurements made at well sites suggest, but under-predicts actual observed subsurface pressures in the region. The analysis presented here is

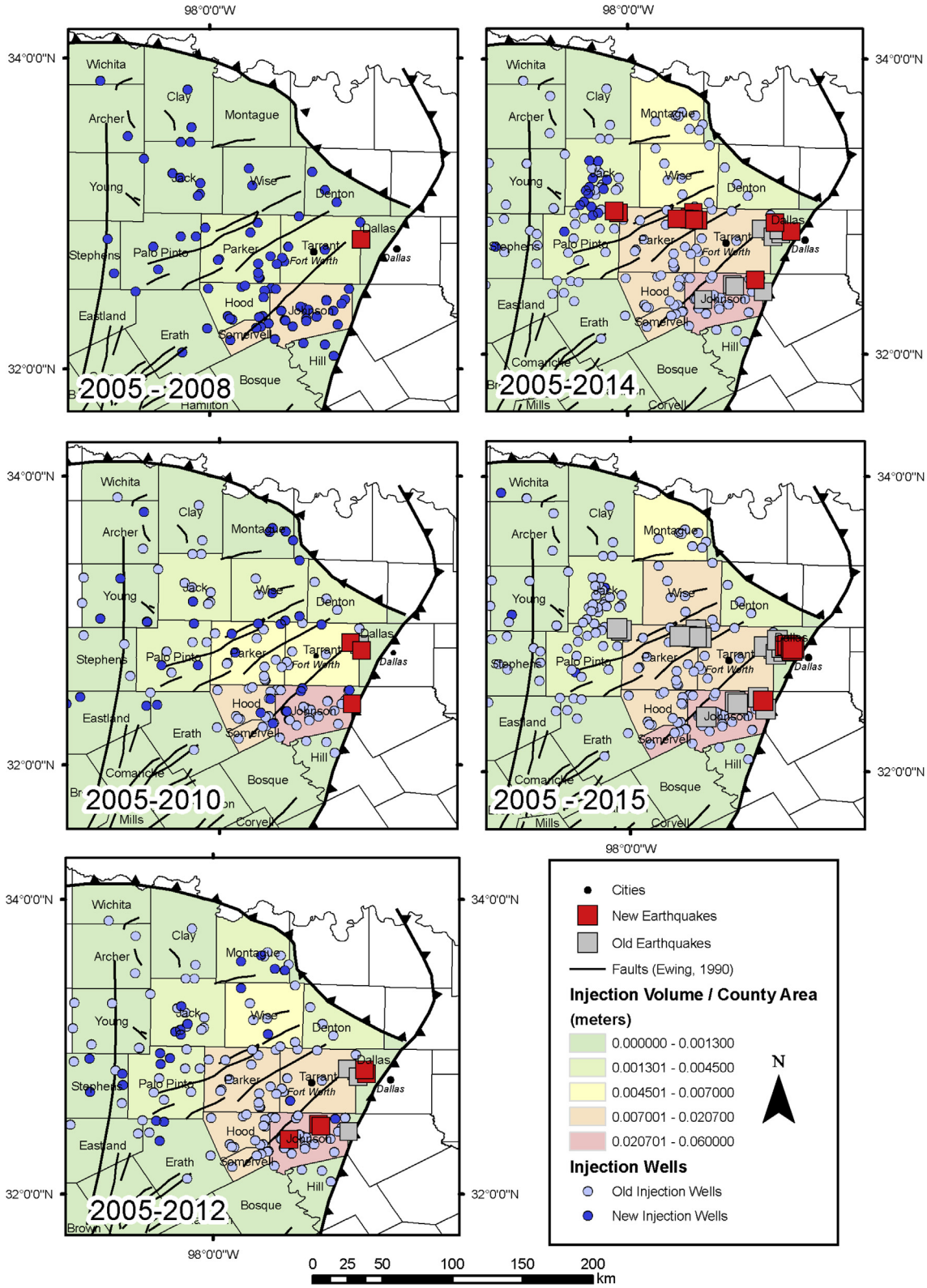

Fig. 7. Time lapse of injection volume per unit area, aggregated by county, and regional seismicity for events of magnitude 3 or greater. Seismicity begins in Eastern Tarrant and Johnson counties, both regions of initially high injection, and spreads both east and west into other areas where injection increases. Note in the last 4 years an increase in permitted injection wells to the north and west.

therefore consistent with regional observations indicating elevated fluid pressures exist and supports previous conclusions suggesting wastewater injection into Ellenburger elevates fluid pressures, promoting seismicity in the region.

4.5. Apparent seismic outliers

The previous investigations (Frohlich et al., 2011; Frohlich, 2012; Justinic et al., 2013; Hornbach et al., 2015) did not provide

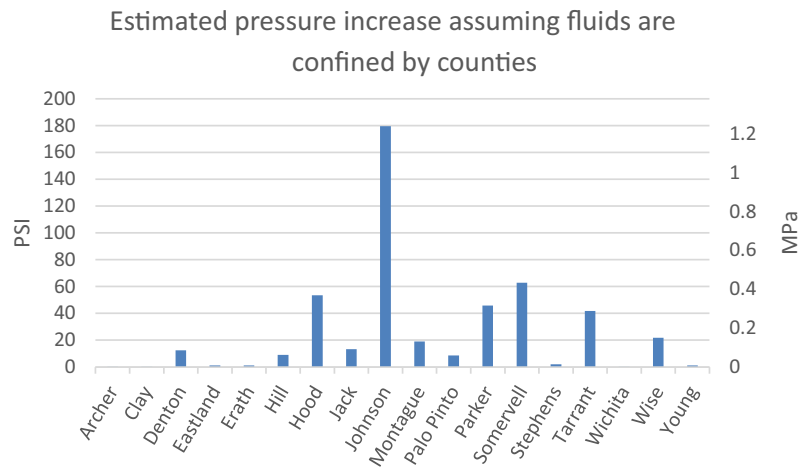

Fig. 8. Estimate of the expected pressure increase in the Ellenburger assuming all injected fluids are confined to the county of injection. In reality, fluid confinement is poorly constrained, and fluids are undoubtedly confined to larger or smaller volumes than those used here, with confinement often leaky. The analysis indicates fluid pressures are highest in Johnson County, but also high in Tarrant, Hood, Somervell, and Parker counties. The only regions where Ellenburger fluid pressures have been measured directly and made publically available are in Johnson and Parker Counties. In both instances, fluid pressures were elevated above values suggested here, with Johnson county measurements 250–650 psi above hydrostatic and Parker county measurements indicating ~70 psi above hydrostatic. Thus the elevated fluid pressures present here are consistent with, but lower than measured values.

an explanation for the occurrence of earthquakes in areas adjacent to, but more distant than a few km from higher-volume injection wells. These include earthquakes in Dallas and Ellis Counties, where no injection wells currently exist, and Palo Pinto County, where injection volumes are moderately low compared to adjacent seismically active counties. Although injection volumes are moderate in Palo Pinto County, the largest injector in the county is located near the two earthquakes in this region (Fig. 6). This, combined with regional fault maps indicating the Mineral Wells Fault may be optimally orientated for failure, with a similar strike to the Newark East Fault near Azle (Hornbach et al., 2015), may explain why earthquakes began in this region in 2013. For the Dallas and Ellis County earthquakes, there are several reasons why these events might not be natural, and instead, induced by wastewater injection:

1. The relatively shallow depths of the earthquakes (<8 km) placing them in the Ellenburger and underlying basement are similar to the depths of likely induced earthquakes near Azle, DFW, and Cleburne. In general, induced earthquakes have shallower hypocenters than natural earthquakes (e.g. Simpson et al., 1988; Ellsworth et al., 2015).
2. Often, induced earthquakes propagate away from an injection well over time, typically over the course of months to years (e.g. Ake et al., 2005; Keranen et al., 2014; Block et al., 2014; Hornbach et al., 2015), and there are documented cases of induced earthquakes more than 10–20 km distant from an injection site (e.g. Healy et al., 1968; Block et al., 2014). Earthquakes were first reported in the basin in 2008 and 2009 in eastern Tarrant and Johnson Counties, with seismicity occurring elsewhere across the region as time passed. The Dallas and Ellis county earthquakes are generally located 10 km or more away from the nearest injector well and did not begin until 6 years after large-scale injection commenced in the surrounding counties. Both counties are located just north and east of Johnson County— the county experiencing by far the largest volume of wastewater injection into the Ellenburger.
3. Large regional faults generally trend in a south-southwest to north-northeast direction across the basin, potentially providing direct pressure communication pathways from high injection zones in Johnson, Somervell, and Tarrant County to Dallas and Irving (Fig. 1, 6 and 7) (e.g. Rozendal and Erskine, 1971; Ewing, 1991; Pollastro et al., 2007; Hentz et al., 2012). Importantly, previous studies indicate critically stressed faults can act as long-distance fluid conduits that have higher permeability than the formation rock (e.g. Hsieh and Bredehoeft, 1981; Barton et al., 1995; Townend and Zoback, 2000). Thus, the idea of km-scale fluid flow along such fault systems is not new. Analysis of regional seismic reflection data revealing fault location and orientations combined with pressure/stress tests in regional wells could rule out or confirm this possibility.
4. Denser fluids will naturally gravitate towards the deepest accessible point, the basin structural axis or localized fault-bounded depocenters, increasing pressure in these areas. Dallas and Ellis counties rest directly above the Ellenburger's deepest point (Core Laboratories Inc, 1972) (Fig. 1). Thus it is plausible that denser brines injected in Parker, Johnson, and Tarrant counties will tend to migrate downslope to Ellis and Dallas counties, and over time increase fluid pressures in the Ellenburger formation there. These increased fluid pressures might trigger earthquakes on faults located in the deepest part of the basin. As noted above, it appears faults with the appropriate orientation already exist to provide high-permeability flow paths for these brines that generate pressure fronts towards Dallas and Ellis County.
5. Unlike the counties where the largest injections volumes occur (Johnson, Parker, and Tarrant counties), the Ellenburger in both Ellis and Dallas Counties is situated down-dip from injection, but is bounded to the east by the Ouachita fold and thrust belt, a massive, nearly impermeable geological boundary (Figs. 1, 5 and 6). The sediments in the Ouachita belt that the Ellenburger terminates against in the eastern edge of the basin consist of low-grade metamorphosed rock, most notably marble, metaquartzite, and quartz diorite (Rozendal and Erskine, 1971). These rocks are significantly less permeable than the Ellenburger. This suggests that fluids cannot easily migrate out of the depocenter below Dallas County since it is bounded by an impermeable feature to the east. Thus once fluids reach the deepest part of the basin below the Dallas-Irving area, they have nowhere else down-dip to migrate, except perhaps along faults. As a result, fluids injected into the Ellenburger in nearby counties may cause pressures to increase steadily over time in the Dallas/Irving area.

We can estimate the permeability necessary for more distant wastewater injection wells to affect faults below the city of Dallas and Irving. Felt earthquakes began in the Irving-Dallas area in early 2014, approximately six years after high injection rates began. We estimate the permeability necessary for the pressure wave to reach Dallas from injectors in both Johnson and Tarrant Counties by solving the characteristic time-pressure diffusion equation for permeability (e.g. Hettema et al., 2002):

$$k = \frac{d^2 \varphi \mu C}{t} \tag{3}$$

Here, d, the distance from a well in Johnson (or Tarrant) county to the center of Dallas county, is 40 (or 15) km; φ, the porosity of the Ellenburger is assumed 4% (Core Laboratories Inc, 1972), μ, the fluid viscosity of the brine, is 4×10^{-4} ($\pm 5 \times 10^{-3}$) Pa s (Texas Railroad commission website); C, the total compressibility of the Ellenburger, is 1.5×10^{-9} ($\pm 0.5 \times 10^{-9}$) Pa[1] (Texas Railroad commission website); and t, the characteristic time it takes for the pressure front to travel 40 and 15 km respectively, is 6 years. Using the 40 km distance for wells in Johnson county to earthquakes in Dallas County, we calculate a permeability of 1–3 $\times 10^{-13}$ m^2 (100–300 mD) is necessary for fluid pressures to travel this distance over 6 years. If we use 15 km, the approximate distance from the Irving-Dallas earthquake sequence to the nearest active injection well in Tarrant county, a permeability of 1–4 $\times 10^{-14}$ m^2 (10–40 mD) is necessary for the pressure wave to travel to the area of seismicity over six years. Measured permeability values for the Ellenburger vary greatly, but usually range between 5×10^{-13} and 1×10^{-15} m^2 (0.1–500 mD) (e.g. Archie, 1952; Core Laboratories Inc, 1972; Hornbach et al., 2015). Our estimated permeability values fall within observed measurements. It therefore is plausible that pressure fronts generated by injectors in neighboring counties could impact Dallas County.

5. Conclusions

Analysis of seismicity, injection volume and pressure measurements for the period 2005–2014 shows that within the Bend-Arch Fort Worth basin, areas where the largest fluid volumes were injected into the Ellenburger were also the areas where compressibility generally decreased, subsurface pressures increased, and earthquakes most often occurred (Figs. 2 and 5–7). The analysis shows not only correlation but causation: lower formation compressibility and higher pressures generally develop at the same time and location where earthquakes occurred. This interpretation is consistent with multiple previous studies conducted decades ago noting both correlation and causation between increased fluid injection volumes, increased pressures, and increased probability of structural failure and associated seismicity with time (e.g. Terzaghi, 1936; Kisslinger, 1976; Talwani and Acree, 1984; Ellsworth et al., 2015).

Of the eight counties in the basin where seismicity has occurred, two (Dallas and Ellis) have no reported injection wells. However, both counties (1) are immediately adjacent to counties where injection volumes are high, (2) are down-dip of the injection zone where denser fluids will flow, (3) are bounded by low permeability sediments of the Ouachita fold and thrust belt that prohibit fluid escape, (4) only began experiencing seismicity after injection began, and (5) are in areas structurally favorable (down-dip) for significant pressure increase. Furthermore, the timing and location of seismicity, developing several years after injection began and more than 10 km from the nearest injector, is similar to induced seismicity observed elsewhere attributed to pressure diffusion across a basin (e.g. Hsieh and Bredehoeft, 1981; Zoback and Hickman, 1982; Simpson et al., 1988; Block et al., 2014) and requires permeabilities consistent with values observed in the Ellenburger. Thus, it is plausible that the seismicity in Dallas and Ellis counties is induced.

In addition, we observe that (1) previous studies suggest the basin has been tectonically inactive for at least 250–300 million years, (2) no earthquakes had been reported in the Dallas-Fort Worth-Arlington area for the past 160 years prior to wastewater injection activity, (3) Dallas-Area earthquake focal depths are in the Ellenburger or the shallow basement beneath, and (4) the seismicity in the basin has spread with time. All these observations are consistent with the hypothesis that earthquakes in the Fort Worth Basin are induced by pressure changes linked to wastewater injection.

Because the subsurface pressure front continues to migrate even after injection ceases, past studies show that it often takes a significant amount of time (months to years) for pressure, and associated seismicity, to reduce to pre-injection levels (e.g. Hsieh and Bredehoeft, 1981; Zoback and Hickman, 1982; Block et al., 2014). Thus, if injection continues into the Ellenburger at rates observed from 2008 to 2014, the analysis broadly suggests that seismicity will continue to occur in Parker, Johnson, Tarrant, Ellis and Dallas Counties along faults optimally oriented for failure. Since not only this study but several others (e.g. Frohlich, 2012; Gono et al., 2015; Frohlich et al., 2016) show a correlation in space and time with large injection volumes and seismicity, one might anticipate seismicity to develop in other areas of the basin with time in locations where injection volumes have been recently increasing (such as Montague and Wise counties) or where the Ellenburger is down-dip of increasing injection volumes or bounded by the Ouachita fold and thrust belt, such as Denton county. Indeed, more detailed microseismicity studies in Montague, Wise, and Denton counties indicate earthquakes have already occurred that are too small to be felt or noticed by local residents (Frohlich, 2012). Nonetheless, injection that increase fluid pressures and reduce effective stress is only one factor influencing induced seismicity. To gain a better understanding of the link between wastewater injection and seismicity, it would be useful to have better information about the locations and orientations of subsurface faults across the basin, and the regional stress regime, especially in areas that are seismically inactive but where future injection is proposed. To assess future hazard, it would also be useful to have measurements of the stress on regional faults. Currently, the orientation of faults with respect to the subsurface stress regime in the basin is only marginally constrained in the public literature (Fig. 5) and this represents an important area of future research for further quantifying the induced seismicity hazard.

Finally, to assess regional seismic hazard—especially in dense urban environments like the Dallas-Fort Worth-Arlington Metroplex—it would be extremely valuable to closely monitor subsurface pressures with time, especially in areas where subsurface pressures may be increasing. As our analysis indicates, injected fluids have the potential to affect subsurface pressures at distances as great as tens of kilometers, with wells in different counties potentially impacting subsurface pressure under the cities of Dallas and Irving. Testing this hypothesis and determining the potential seismic hazard in the DFW area ultimately requires more detailed stress and fault maps combined with high-quality pressure monitoring within and below the Ellenburger formation. Currently, no standard or routine formation pressure monitoring program exists in the Ellenburger. Monthly well head injection pressures provided to the Texas Railroad Commission are only a rough proxy for understanding changes in formation compressibility, and currently, there are no baseline or time-dependent pressure measurements in the deepest part of the basin, directly below the cities of Dallas and Irving where seismicity could be most damaging. The

recommendation to monitor subsurface pressure is a not a new idea; it was made nearly 50 years ago by both industry and academic researchers (e.g. Van Everdingen, 1968; Galley, 1968, and references therein) when injection strategies were first considered. It is a recommendation that remains even more valid and relevant today than it was 50 years ago.

Acknowledgments

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References

Ake, J., Mahrer, K., O'Connell, D., Block, L., 2005. Deep-injection and closely monitored induced seismicity at Paradox Valley, Colorado. Bull. Seismol. Soc. Am. 95 (2), 664–683.
Archie, G.E., 1952. Classification of carbonate reservoir rocks and petrophysical considerations. AAPG Bulletin 36 (2), 278–298.
Autry, V.E., 1940. Discovery of oil in Ellenburger Formation, KMA Oil Field, Wichita County, Texas: Geological Notes. AAPG Bulletin 24 (8), 1494–1495.
Barton, C.A., Zoback, M.D., Moos, D., 1995. Fluid flow along potentially active faults in crystalline rock. Geology 23 (8), 683–686.
Block, L.V., Wood, C.K., Yeck, W.L., King, V.M., 2014. The 24 January 2013 ML 4.4 earthquake near Paradox, Colorado, and its relation to deep well injection. Seismol. Res. Lett. 85 (3), 609–624.
Bowker, K.A., 2007. Barnett Shale gas production, Fort Worth Basin: issues and discussion. AAPG Bulletin 91 (4), 523–533.
Brace, W., Walsh, J.B., Frangos, W.T., 1968. Permeability of granite under high pressure. J. Geophys. Res. 73 (6), 2225–2236.
Bradfield, H.H., 1964. The Ellenburger Group of north central Texas. Tulsa Geological Society Digest 32, 112–118.
Budnik, R.T., Ames, J.T., Ridner, D.M., 1990. University of Texas at Austin. Bureau of Economic Geology. Tectonic Map of Texas. Bureau of Economic Geology, University of Texas at Austin.
Core Laboratories, Inc, 1972. A Survey of Subsurface Saline Waters of Texas. Texas Water Development Board Report, vol. 157, 113 pp.
Ellsworth, W.L., 2013. Injection-induced earthquakes. Science 341 (6142), 1225942.
Ellsworth, W.L., Llenos, A.L., McGarr, A.F., Michael, A.J., Rubinstein, J.L., Mueller, C.S., Petersen, M.D., Calais, E., 2015. Increasing seismicity in the US midcontinent: Implications for earthquake hazard. The Leading Edge 34 (6), 618–626.
Ewing, T.E., 1991. The Tectonic Framework of Texas: Text to Accompany" The Tectonic Map of Texas. Bureau of Economic Geology. University of Texas, Austin.
Frohlich, C., Davis, S.D., 2002. Texas Earthquakes (No. 2). University of Texas Press, 275 pp..
Frohlich, C., Hayward, C., Stump, B., Potter, E., 2011. The Dallas-Fort Worth earthquake sequence: October 2008 through May 2009. Bull. Seismol. Soc. Am. 101 (1), 327–340.
Frohlich, C., 2012. Two-year survey comparing earthquake activity and injection-well locations in the Barnett Shale, Texas. Proc. Natl. Acad. Sci. 109 (35), 13934–13938.
Frohlich, C., DeShon, H., Stump, B., Hayward, C., Hornbach, M., Walter, J.I., 2016. A historical review of induced earthquakes in Texas. Seismol. Res. Lett. 87, 1022–1038.
Gale, J.F., Reed, R.M., Holder, J., 2007. Natural fractures in the Barnett Shale and their importance for hydraulic fracture treatments. AAPG Bulletin 91 (4), 603–622.
Galley, J.E. (Ed.), 1968. Subsurface Disposal in Geologic Basins: A Study of Reservoir Strata, vol. 10. American Association of Petroleum Geologists.
Géraud, Y., 1994. Variations of connected porosity and inferred permeability in a thermally cracked granite. Geophys. Res. Lett. 21 (11), 979–982.
Gono, V., Olson, J.E., Gale, J.F., 2015. November. Understanding the correlation between induced seismicity and wastewater injection in the Fort Worth Basin, 49th US Rock Mechanics/Geomechanics Symposium. American Rock Mechanics Association.
Gregory, K.B., Vidic, R.D., Dzombak, D.A., 2011. Water management challenges associated with the production of shale gas by hydraulic fracturing. Elements 7 (3), 181–186.
Hentz, T.F., Ambrose, W.A., Carr, D.L., 2012. Reservoir systems of the Pennsylvanian lower Atoka Group (Bend Conglomerate), northern Fort Worth Basin, Texas: High-resolution facies distribution, structural controls on sedimentation, and production trends. AAPG Bulletin 96 (7), 1301–1332.
Hanks, T.C., Kanamori, H., 1979. A moment magnitude scale. J. Geophys. Res. B 84 (B5), 2348–2350.
Healy, J.H., Rubey, W.W., Griggs, D.T., Raleigh, C.B., 1968. The Denver earthquakes. Science 161 (3848), 1301–1310.
Heidbach, O., Tingay, M., Barth, A., Reinecker, J., Kurfeß, D., Müller, B., 2008. The World Stress Map database release. http://dx.doi.org/10.1594/GFZ.WSM.
Hettema, M., Papamichos, E., Schutjens, P.M.T.M., 2002. Subsidence delay: Field observations and analysis. Oil & Gas Science and Technology 57 (5), 443–458.
Hornbach, M.J., DeShon, H.R., Ellsworth, W.L., Stump, B.W., Hayward, C., Frohlich, C., Oldham, H.R., Olson, J.E., Magnani, M.B., Brokaw, C., Luetgert, J.H., 2015. Causal factors for seismicity near Azle. Texas. *Nature Communications* 6, 6728.
Hsieh, P.A., Bredehoeft, J.D., 1981. A reservoir analysis of the Denver earthquakes: A case of induced seismicity. Journal of Geophysical Research: Solid Earth 86 (B2), 903–920.
Huffman Jr, A.C., 2003. Middle Pennsylvanian tectonics of the conterminous United States SEPM Special Publication No. 77, ISBN 1-56576-085-9, p. 73-94.
Jarvie, D.M., Hill, R.J., Ruble, T.E., Pollastro, R.M., 2007. Unconventional shale-gas systems: The Mississippian Barnett Shale of north-central Texas as one model for thermogenic shale-gas assessment. AAPG Bulletin 91 (4), 475–499.
Justinic, A.H., Stump, B., Hayward, C., Frohlich, C., 2013. Analysis of the Cleburne, Texas earthquake sequence from June 2009 to June 2010. Bull. Seismol. Soc. Am. 103. http://dx.doi.org/10.1785/0120120336, 3083-3093.
Keranen, K.M., Weingarten, M., Abers, G.A., Bekins, B.A., Ge, S., 2014. Sharp increase in central Oklahoma seismicity since 2008 induced by massive wastewater injection. Science 345 (6195), 448–451.
Khatiwada, M., Keller, G.R., Marfurt, K.J., 2013. A window into the Proterozoic: Integrating 3D seismic, gravity, and magnetic data to image subbasement structures in the southeast Fort Worth basin. Interpretation 1 (2), T125–T141.
Kisslinger, C., 1976. A review of theories of mechanisms of induced seismicity. Eng. Geol. 10 (2), 85–98.
Loucks, R.G., Anderson, J.H., 1985. Depositional facies, diagenetic terranes, and porosity development in Lower Ordovician Ellenburger Dolomite, Puckett field, west Texas. In: Carbonate Petroleum Reservoirs (Pp. 19-37). Springer, New York.
Loucks, R.G., Reed, R.M., Ruppel, S.C., Jarvie, D.M., 2009. Morphology, genesis, and distribution of nanometer-scale pores in siliceous mudstones of the Mississippian Barnett Shale. J. Sediment. Res. 79 (12), 848–861.
McDonnell, A., Loucks, R.G., Dooley, T., 2007. Quantifying the origin and geometry of circular sag structures in northern Fort Worth Basin, Texas: Paleocave collapse, pull-apart fault systems, or hydrothermal alteration? AAPG Bulletin 91, 1295–1318.
McGarr, A., 2014. Maximum magnitude earthquakes induced by fluid injection. Journal of Geophysical Research: Solid Earth 119 (2), 1008–1019.
McLatchie, A.S., Hemstock, R.A., Young, J.W., 1958. The effective compressibility of reservoir rock and its effects on permeability. J. Petrol. Technol. 10 (06), 49–51.
Montgomery, S.L., Jarvie, D.M., Bowker, K.A., Pollastro, R.M., 2005. Mississippian Barnett Shale, Fort Worth basin, north-central Texas: Gas-shale play with multi–trillion cubic foot potential. AAPG Bulletin 89 (2), 155–175.
Muehlberger, W.R., 1965. Late Paleozoic movement along the Texas lineament. Transactions of the New York Academy of Sciences 27 (4), 385–392, Series II.
National Research Council (US), 2013. Committee on Induced Seismicity Potential in Energy Technologies. In: Induced Seismicity Potential in Energy Technologies. National Academies Press.
Nicot, J.P., Scanlon, B.R., Reedy, R.C., Costley, R.A., 2014. Source and fate of hydraulic fracturing water in the Barnett Shale: a historical perspective. Environ. Sci. Technol. 48 (4), 2464–2471.
Pollastro, R.M., Hill, R.J., Jarvie, D.M., Henry, M.E., 2003. Assessing undiscovered resources of the Barnett-Paleozoic total petroleum system, Bend Arch-Fort Worth Basin Province, Texas. AAPG Search and Discovery Article #10034, 1–17.
Pollastro, R.M., Jarvie, D.M., Hill, R.J., Adams, C.W., 2007. Geologic framework of the Mississippian Barnett Shale, Barnett-Paleozoic total petroleum system, Bend Arch-Fort Worth Basin. Texas. *AAPG Bulletin* 91 (4), 405–436.
Reasenberg, P.A., Simpson, R.W., 1992. Response of regional seismicity to the static stress change produced by the Loma Prieta earthquake. Science 255 (5052), 1687–1690.
Rozendal, R.A., Erskine, W.S., 1971. Deep test in Ouachita structural belt of central Texas. AAPG Bulletin 55 (11), 2008–2017.
Rubinstein, J.L., Mahani, A.B., 2015. Myths and facts on wastewater injection, hydraulic fracturing, enhanced oil recovery, and induced seismicity. Seismol. Res. Lett. 86 (4), 1060–1067.
Simpson, D.W., Leith, W.S., Scholz, C.H., 1988. Two types of reservoir-induced seismicity. Bull. Seismol. Soc. Am. 78 (6), 2025–2040.
Skoczylas, F., Henry, J.P., 1995. February. A study of the intrinsic permeability of granite to gas. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts 32 (2), 171–179, Pergamon.
Stein, R.S., 1999. The role of stress transfer in earthquake occurrence. Nature 402 (6762), 605–609.
Sullivan, E.C., Marfurt, K.J., Lacazette, A., Ammerman, M., 2006. Application of new seismic attributes to collapse chimneys in the Fort Worth Basin. Geophysics 71 (4), B111–B119.
Talwani, P., Acree, S., 1984. Pore pressure diffusion and the mechanism of reservoir-induced seismicity. Pure Appl. Geophys. 122 (6), 947–965.
Terzaghi, V.K., 1936. The shearing resistance of saturated soils and the angle between the planes of shear, Proceedings of the 1st international conference on soil mechanics and foundation engineering (Vol. 1, pp. 54–56). Harvard University Press, Cambridge, MA.
Terzaghi, K., 1943. Fundamentals of Soil Mechanics. Wiley, New York.
Townend, J., Zoback, M.D., 2000. How faulting keeps the crust strong. Geology 28 (5), 399–402.
Van Everdingen, A.F., 1968. Fluid mechanics of deep-well disposals. In: Galley, J.E. (Ed.), Subsurface Disposal in Geologic Basins: A Study of Reservoir Strata. AAPG Memoir 10, pp. 32–42.

Walsh, F.R., Zoback, M.D., 2015. Oklahoma's recent earthquakes and saltwater disposal. Science Advances 1 (5), e1500195.
Weingarten, M., Ge, S., Godt, J.W., Bekins, B.A., Rubinstein, J.L., 2015. High-rate injection is associated with the increase in US mid-continent seismicity. Science 348 (6241), 1336–1340.
Zoback, M.D., Hickman, S., 1982. In situ study of the physical mechanisms controlling induced seismicity at Monticello Reservoir, South Carolina. Journal of Geophysical Research: Solid Earth (1978–2012) 87 (8), 6959–6974, B.
Zoback, M.L., Zoback, M., 1980. State of stress in the conterminous United States. Journal of Geophysical Research: Solid Earth 85 (B11), 6113–6156.

APPENDIX

V-2 Fault Slip Potential Analysis

ALL CONSULTING
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ENGINEERING · ENVIRONMENTAL

Technical Memorandum

To: *Gary McCuistion / Republic Services*

From: *Dan Arthur / ALL Consulting*

CC: *Tom Tomastik / ALL Consulting*
Reed Davis / ALL Consulting
Fernando DeLeon / ALL Consulting

Date: *January 20, 2020*

Re: *Technical Assessment of the Vortex Disposal Well and Itasca Landfill Site for Class I Non-Hazardous Injection Well for Leachate Disposal*

Introduction

ALL Consulting LLC (ALL) was previously contracted by Republic Services (Republic) to perform an initial high-level cost estimate for budget planning and analysis purposes for the Vortex SWD #1 (Vortex) well. This cost estimate is for oversight of the permitting, testing and surface facility review for converting or otherwise re-permitting the existing Vortex Class II well to a Class I Non-Hazardous Injection Well for purposes of disposing of landfill leachate. The technical memorandum was submitted to Republic on March 27, 2018.

In late November of 2019, Republic requested that ALL perform a more in-depth technical assessment of the conversion of the Vortex well in Johnson County, Texas, to Class I and to evaluate the feasibility of drilling a new Class I non-hazardous disposal well at Republic's Itasca Landfill, which is located in Hill County, Texas. This new assessment of both locations includes an updated area of review (AOR) evaluation, an evaluation for seismicity and faulting, and the modeling of the fault slip potential (FSP) at these locations to analyze the potential risk for induced seismicity. Additionally, ALL has provided an updated cost estimate to Republic to convert the Vortex well to a Class I well.

Class I Injection in Texas and Regulatory Authority

The state of Texas has primacy of its Class I and Class II underground injection control (UIC) programs. All Class I permitting and regulatory authority is through the Texas Commission on Environmental Quality (TCEQ), while all Class II permitting and regulatory authority is through the Texas Railroad Commission (TRRC). TCEQ has developed Class I injection well application guidance to assist applicants with the permitting process. This Class I permit application guidance includes a list of some of the requirements for an approved Class I permit:

- Submittal of actual as-built drawings and well completion data;
- Completion of required geophysical logging and testing requirements;
- A demonstration of external and internal mechanical integrity;

- Anticipated regulatory maximum pressure and flow rate at which the permittee will operate;
- Submittal of injection zone and confining zone testing as required;
- Address of the compatibility of injected wastes with fluids in both the injection zone and the confining zone and with materials used to construct the well;
- Completion of a 2.5-mile AOR and cone of influence based on data obtained during logging and testing of the well and the formation; and
- Compliance with the casing and cementing performance standards set forth in 30 TAC (Texas Administrative Code) §331.62(a)(1).

The typical permitting timeframe for a Class I non-hazardous injection well application with TCEQ is approximately 12-14 months. Even though the state of Texas has primacy of the Class I UIC program, depending on the nature of the surface requirements and possible zoning, the local municipality or the county may have some oversight of surface construction operations that may require additional permitting. Testing and any new surface facility construction could likely add additional time and costs to the total completion of a Class I well.

Technical Evaluation of the Vortex Well

The Vortex well (API No. 251-31020) was completed in the Ellenburger Formation (Ellenburger) in 2006. There was 1,766 feet of 9-5/8" surface casing set and cemented to surface. The 7" production casing was run to total depth of 11,250 feet and cemented to surface in multiple stages. The top of the Ellenburger was encountered at a depth of 7,954 feet. The permitted injection interval in the Ellenburger was from 8,600 to 11,235 feet, but the well was only perforated from 10,430 to 11,235 feet in the Ellenburger. The 4-1/2" injection tubing was set on a packer at a depth of 10,376 feet.

ALL has further evaluated the available resistivity geophysical log for the Vortex well and there are multiple zones within the Ellenburger from 8,620 to 9,680 feet that have low resistivity readings and are viable for disposal. **Figure 1** is a snip of this resistivity log showing one of the new potential injection intervals that could be perforated in the Vortex well. ALL recommends

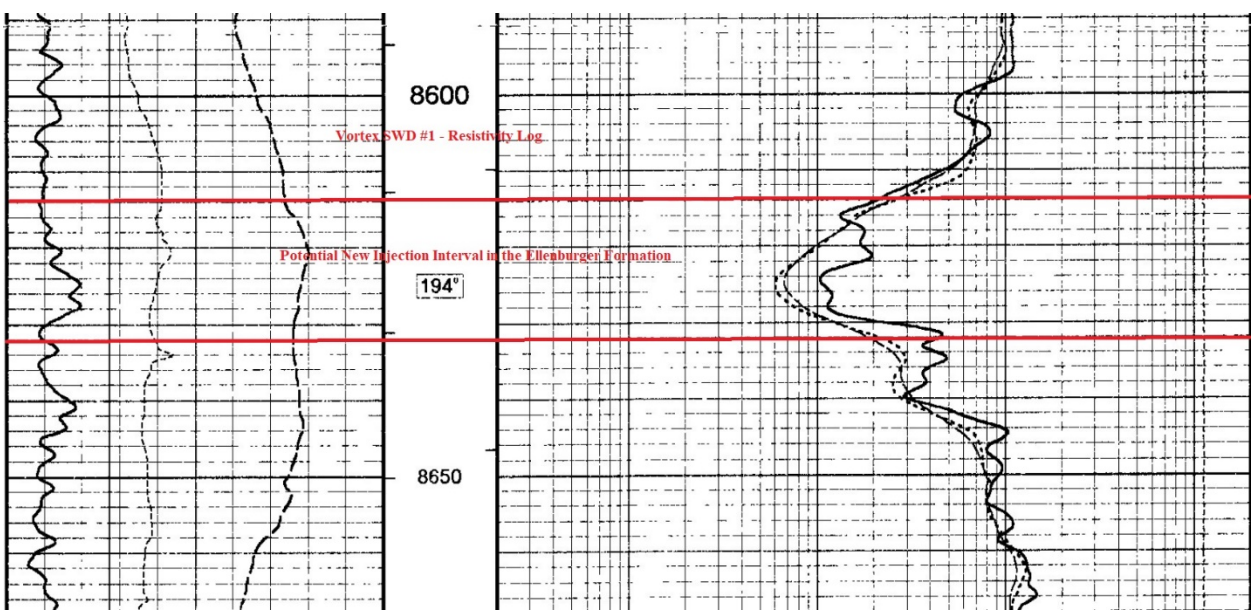

Figure 1. New Potential Shallower Injection Interval in the Ellenburger in the Vortex SWD #1 Well

that if the Vortex well is to be converted to Class I, that Republic consider perforating these higher zones in the Ellenburger, which will reduce tubing costs and increase injection capacity.

During ALL's preliminary review of the Vortex well construction, ALL had a concern that the surface casing in the Vortex well may not be deep enough to allow for conversion to Class I. ALL requested that TRRC perform an evaluation of the surface casing depth. On January 2, 2020, ALL received the response back from TRRC and the base of the deepest source of underground drinking water (USDW) is at 1,750 feet, so the Vortex well has 16 feet of surface casing below the deepest USDW and appears to satisfy the TCEQ requirements for setting surface casing past the USDW and into the lower confining unit.

ALL performed the 2.5-mile AOR for the Vortex site and there were 306 wells or proposed well locations within the Vortex AOR. Only one well penetrates the proposed Vortex injection interval in the Ellenburger, and that well is an existing Class II disposal well (API No. 251-32327). The other existing disposal well is approximately one mile north of the Vortex well location. This well is operated by Bosque Disposal Systems, LLC (Bosque) and is completed open hole in the Ellenburger from a depth of 9,104 to 11,250 feet. There is a possibility that Bosque might file a protest with the TCEQ claiming well inference, but it may not be issue since Republic's proposed disposal rates of leachate will be lower than a normal Class II well.

Technical Evaluation of the Itasca Landfill Site

ALL has performed a technical assessment of the proposal for the drilling and completion of a new Class I non-hazardous disposal well at the existing Itasca Landfill to handle the disposal of the landfill leachate. The 2.5-mile AOR identified only two wells within the AOR. One well within the AOR (API No. 217-30529) is supposedly drilled into the Ellenburger at a depth of 10,000 feet, but the well is a horizontal Barnett Shale well and it looks to be plugged back to 9,235 feet. **Figure 2** is a map showing the location of the Itasca Landfill and this well that penetrated the Ellenburger. Additionally, the well completion record on file with TRRC indicates that the well has not been perforated or fraced and that there are 8-3/4" plugs set at 8,532 and 8,366 feet.

Unfortunately, there were no geophysical logs available for this well. Since this is the only deep well in this area, it looks like the Ellenburger is deeper than in the Vortex well, perhaps from 10,000 to 12,000 feet below the surface. Even though there is limited geological information on the Ellenburger in this area, ALL knows the Ellenburger well and the Itasca Landfill site should be a suitable site for leachate disposal into the Ellenburger.

Seismic Assessment and Evaluation of FSP

ALL has performed a seismic assessment and FSP analysis for both the Vortex and the Itasca Landfill locations. FSP analysis is modeled using a 5.64-mile radius area of interest (AOI) around each proposed Class I location. Precambrian faults were identified from published material and were utilized in the evaluation of the FSP. There was only one fault within the Itasca Landfill, while there were ten faults identified in the AOI of the Vortex well. Additionally, ALL modeled the FSPs at three different injection rates of 5,000 barrels of water per day (bwpd), 10,000 bwpd, and at 15,000 bwpd, even though Republic's leachate injection rates would be anticipated to be

Figure 2. Map Showing the Location of the Itasca Landfill and the Well Penetrating the Ellenburger

much lower. The complete FSP analysis for both sites are attached in **Appendix A**. Based on the FSP analysis performed by ALL, both proposed Class I locations had very low FSPs, which means there is little to no risk of these wells inducing seismic activity.

Vortex Updated Cost Estimates

ALL has prepared some updates to the cost estimates for each category to permit, test, and operate a Class I non-hazardous injection well at the Vortex site. These cost estimates are summarized below and are provided in **Appendix B** with further detail.

TYPE OF SERVICES	ESTIMATED COST RANGE
Regulatory and Permitting of Class I Well	$125,000 - $150,000
Logging and External MI Testing	$160,000 - $175,000
Replacement of Tubing and Packer Internal MI Testing	$340,000 - $360,000
Surface Facility Construction	$350,000 - $500,000
TOTAL COST ESTIMATES	**$975,000 - $1,200,000**
Operation Costs	$900,000 - $1,000,000 per year

Based on ALL's high-level cost estimates for the permitting, testing, and surface facility review and for the conversion of Vortex well to a Class I non-hazardous waste injection well located in Johnson County, Texas, this initial cost estimate is approximately $975,000 - $1,200,000. Annual

estimated operating costs for a 24/7-and-365-day-a-year operation would be approximately $1,000,000 per year.

If Republic decides to move forward with this Class I non-hazardous injection well conversion proposal, ALL recommends preparing an actual Authorization for Expenditure (AFE) to obtain detailed design costs and gathering quotes by contacting various service companies and contractors, so a more detailed budgetary analysis can be undertaken.

Conclusions and Recommendations

ALL has completed its preliminary technical assessment of the conversion of the Vortex well from Class II to Class I disposal and the drilling and completion of a new Class I disposal well at the Itasca Landfill. Based on this preliminary assessment, both locations look to be feasible for Class I operations, but ALL recommends a pre-application meeting with the TCEQ prior to moving forward with either application to ensure all technical and regulatory issues can be addressed. Furthermore, ALL's seismic evaluation and FSP analysis confirms that both sites present little to no risk for disposal operations inducing seismic activity.

Appendix A

Fault Slip Potential Analysis

Republic Services

Fault Slip Potential Analysis – Vortex and Itasca Landfill Sites

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FSP Methodology

- 2 FSP areas (100 square miles each) in Fort Worth Basin centered around Republic Vortex SWD and Itasca Landfill sites.
- Geologic conditions of the FSP areas are derived from nearby well logs.
- Each scenario modeled over 25 years. Stress gradients and pore pressure gradients derived from published papers (Hennings et al 2019).
- Reference depth, injection interval thickness, porosity, and permeability derived from nearby geophysical logs penetrating the injection interval (Texas RRC 2020, see appendix).
- One mapped Precambrian fault in the 100 square mile area of review for the Itasca Landfill site. Ten mapped Precambrian faults in the 100 square mile area of review for the Vortex SWD site. (USGS 2019, Ruppel et al 2005, and Hennings et al 2019).
- Mapped Precambrian faults are assumed to penetrate upwards into the Ellenburger for the purpose of modeling only. Mapped faults are only known to exist within the Precambrian basement (Hennings et al 2019).

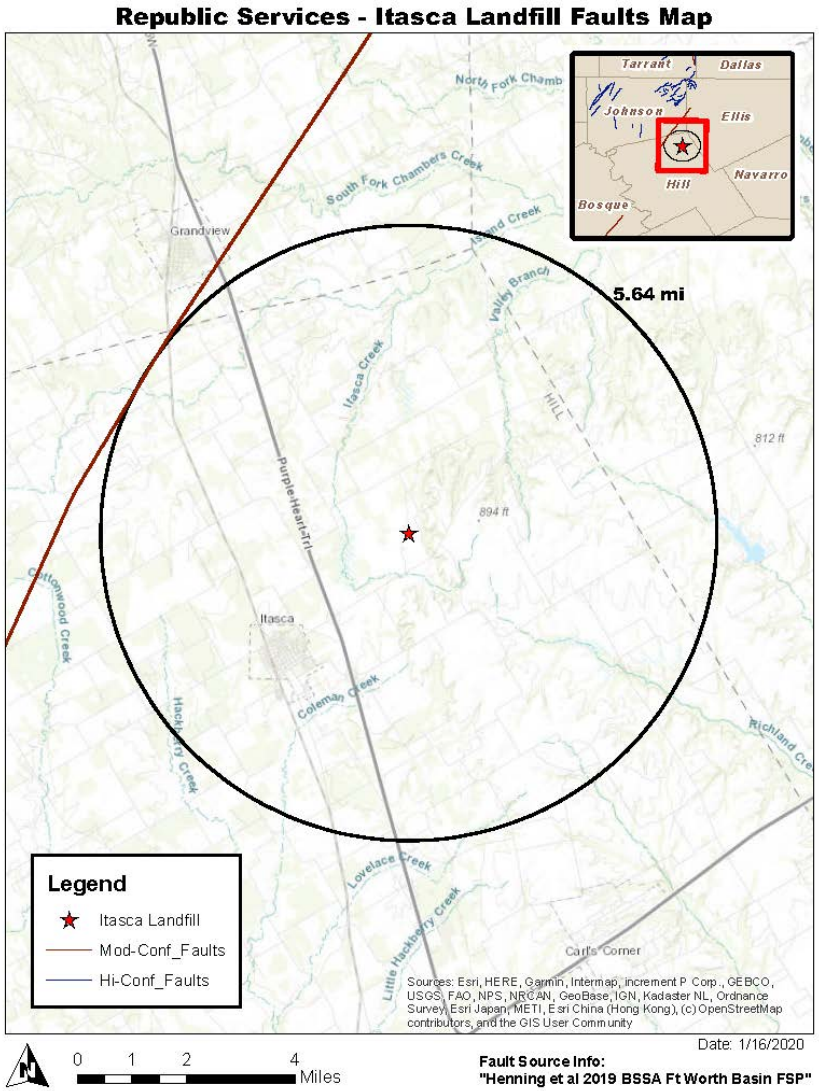
Parameters

Parameter	Value	Source
Vertical Stress Gradient (psi/ft)	1.15	Hennings et al (2019)
Horizontal Stress Direction (degrees azimuth)	25	Hennings et al (2019)
Reference Depth (ft)	8,000 – 10,000	Well Logs TX RRC (2020)
Initial Reservoir Pressure Gradient (psi/ft)	0.491	Hennings et al (2019)
A Phi	0.8 (normal faulting)	Hennings et al (2019)
Friction Coefficient	0.8	Hennings et al (2019)
Injection Zone Thickness (ft)	2,900	Well Logs TX RRC (2020)
Porosity (%)	8	Well Logs TX RRC (2020)
Permeability (mD)	50	Well Logs TX RRC (2020)
Fault Strike Minimum (degrees)	-40	Hennings et al (2019)
Fault Strike Maximum (degrees)	80	Hennings et al (2019)
Fault Dip Minimum (degrees)	50	Hennings et al (2019)
Fault Dip Maximum (degrees)	90	Hennings et al (2019)
Density (kg/m^3)	1000	ALL Research (2020)
Dynamic Viscosity (Pa*s)	0.0003	ALL Research (2020)
Fluid Compressibility (Pa^-1)	4.70E-10	ALL Research (2020)
Rock Compressibility (Pa^-1)	8.70E-10	ALL Research (2020)

Injection Data

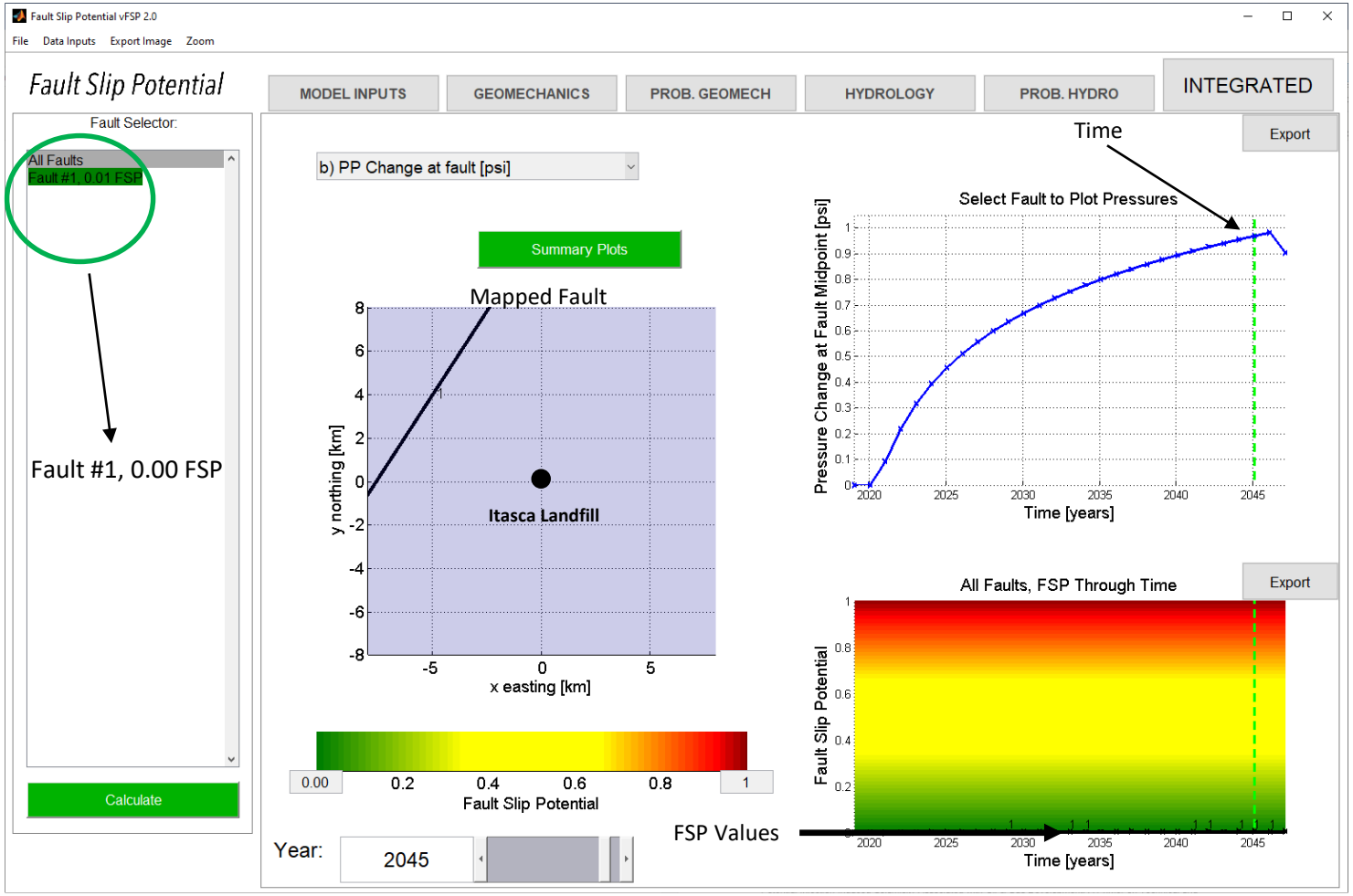
- No deep class II injection wells active within Itasca Landfill 5.64-mile area of interest (TX RRC 2020).
- There are two other active deep class II injection wells within Vortex SWD 5.64-mile area of interest (TX RRC 2020).
- Active deep class II injection wells modeled at maximum permitted injection rates (see appendix).
- Proposed Republic Class I SWDs modeled at three injection rates - 5,000 bwpd, 10,00 bwpd, and 20,000 bwpd.

Itasca Landfill FSP Area



ALL CONSULTING
GOVERNMENT RELATIONS · ENERGY · PLANNING · TECHNOLOGY
ENGINEERING · ENVIRONMENTAL

FSP After 25 Years – Itasca Landfill – 5,000 bpd



● = Proposed Republic SWD

Parameters

Estimated Porosity
8%

Estimated Permeability
100 mD

Estimated Injection Interval
10,000 – 12,900 ft

Mapped Fault

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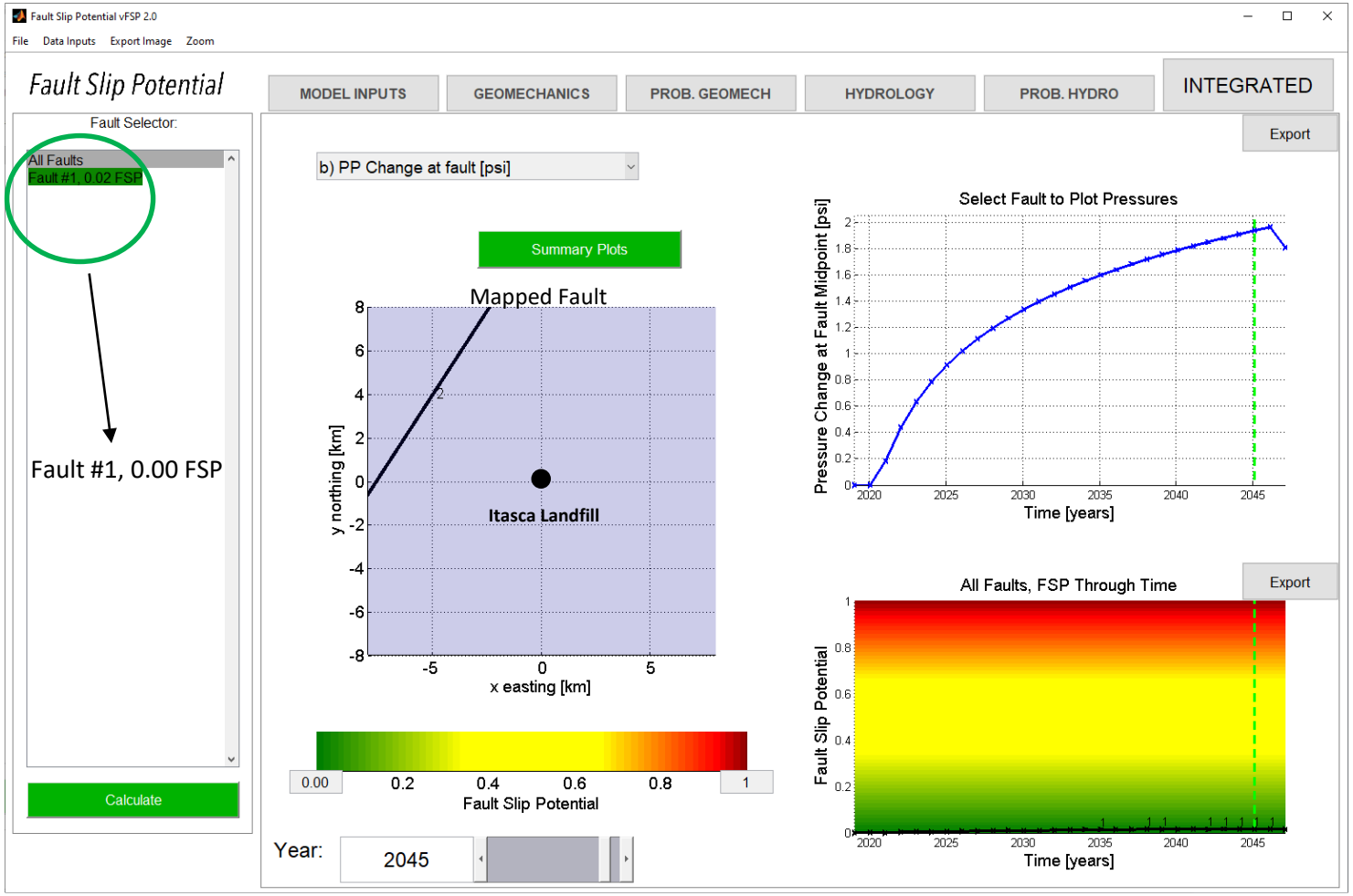
ENGINEERING · ENVIRONMENTAL

FSP After 25 Years – Itasca Landfill – 10,000 bpd



● = Proposed Republic SWD

Parameters

Estimated Porosity
8%

Estimated Permeability
100 mD

Estimated Injection Interval
10,000 – 12,900 ft

Mapped Fault

ALL CONSULTING
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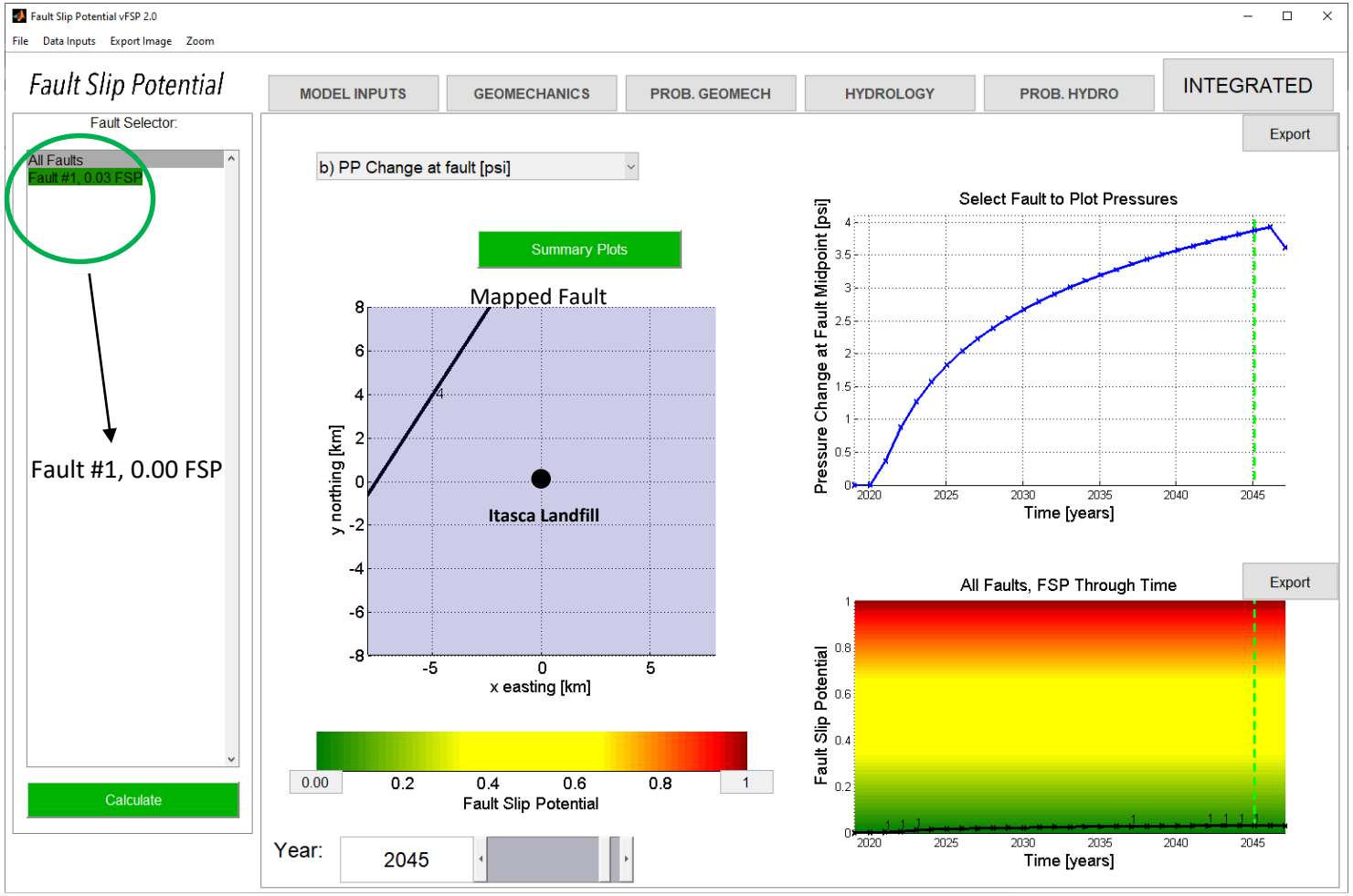
FSP After 25 Years – Itasca Landfill – 20,000 bpd



● = Proposed Republic SWD

Parameters

Estimated Porosity
8%

Estimated Permeability
100 mD

Estimated Injection Interval
10,000 – 12,900 ft

Mapped Fault

ALL CONSULTING
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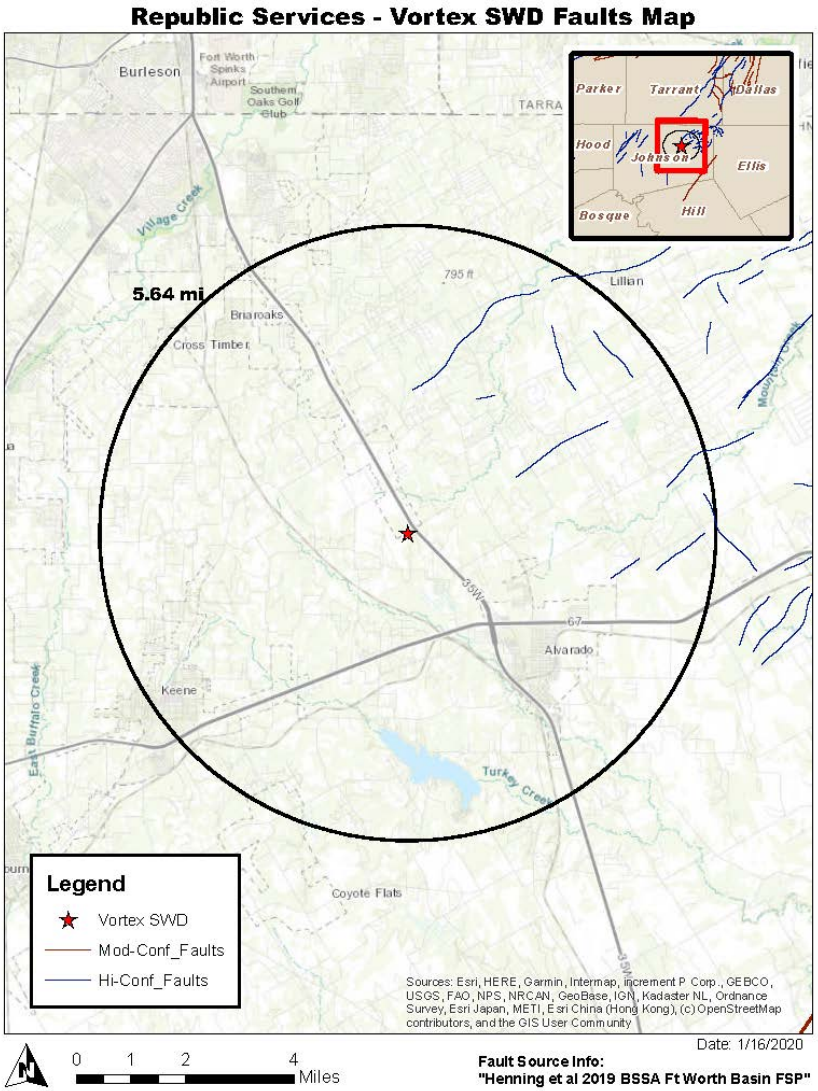
ENGINEERING · ENVIRONMENTAL

Vortex SWD FSP Area



ALL CONSULTING
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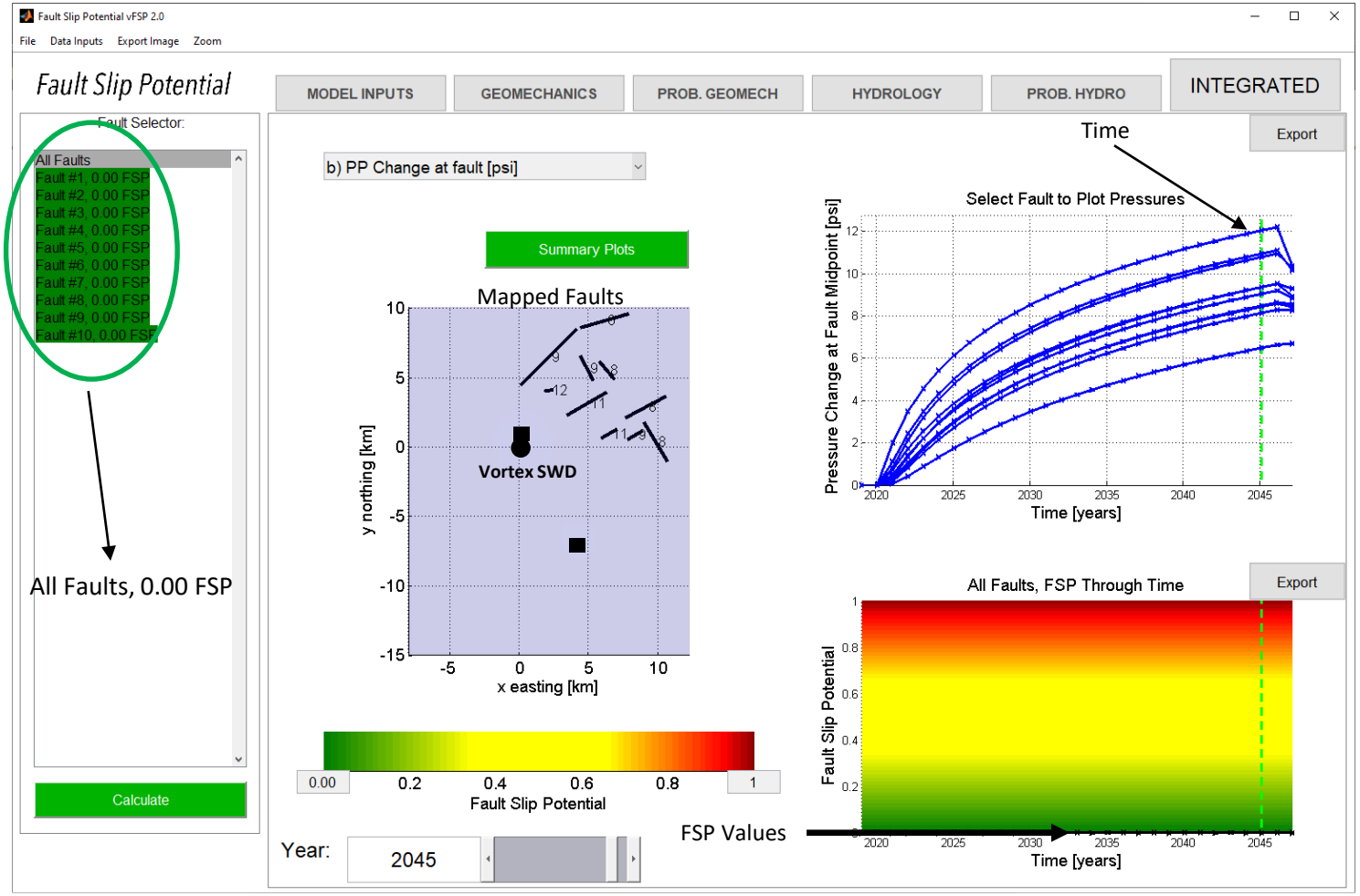
ENGINEERING · ENVIRONMENTAL

FSP After 25 Years – Vortex SWD – 5,000 bpd



● = Proposed Republic SWD

■ = Active Deep SWDs

Parameters

Estimated Porosity
8%

Estimated Permeability
100 mD

Estimated Injection Interval
8,600 – 11,500 ft

Mapped Faults

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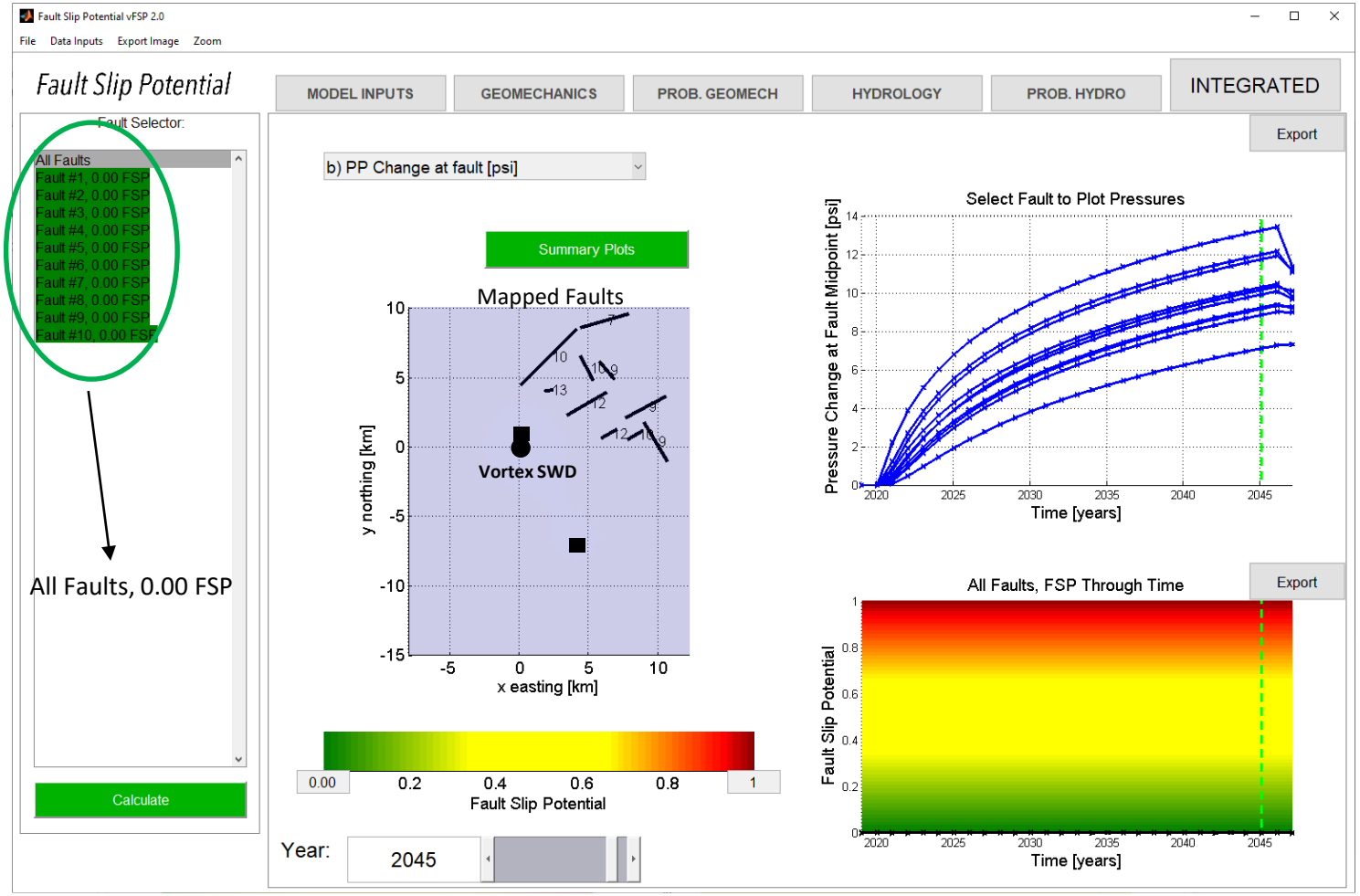
ENGINEERING · ENVIRONMENTAL

FSP After 25 Years – Vortex SWD – 10,000 bpd



● = Proposed Republic SWD

■ = Active Deep SWDs

Parameters

Estimated Porosity
8%

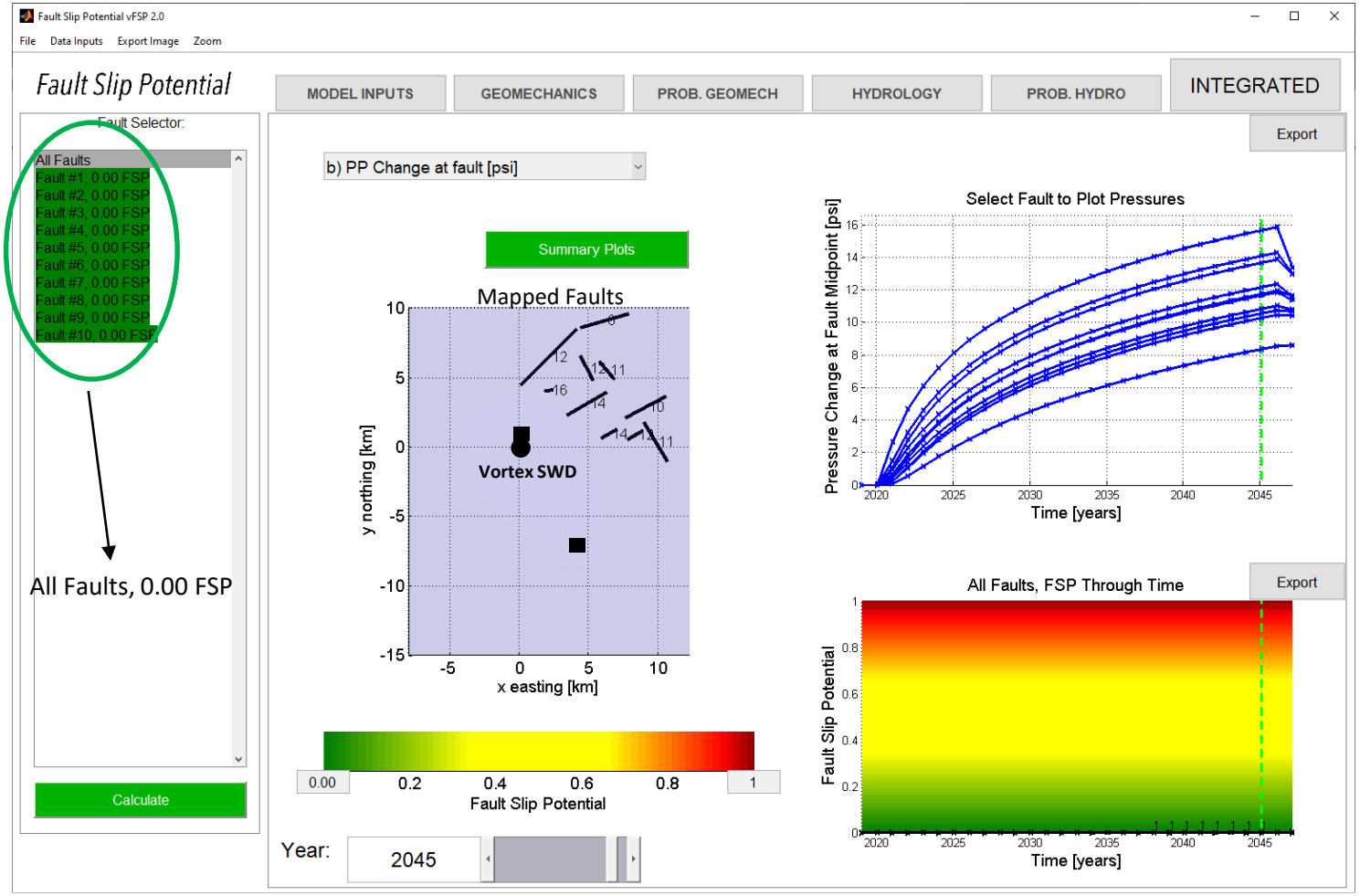
Estimated Permeability
100 mD

Estimated Injection Interval
8,600 – 11,500 ft

Mapped Faults

ALL CONSULTING
GOVERNMENT RELATIONS · ENERGY · PLANNING · TECHNOLOGY
ENGINEERING · ENVIRONMENTAL

FSP After 25 Years – Vortex SWD – 20,000 bpd



● = Proposed Republic SWD

■ = Active Deep SWDs

Parameters

Estimated Porosity
8%

Estimated Permeability
100 mD

Estimated Injection Interval
8,600 – 11,500 ft

Mapped Faults

ALL CONSULTING
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Nearby Deep Class II SWD Injection Data Used in FSP Analysis

Republic - Deep SWDs Within FSP Areas		
FSP Area	**API #**	**Permitted Daily Injection Rate (BWPD)**
Vortex	251-31021	25,000
Vortex	251-32327	30,000

Data Source: Texas RRC 2020

Conclusions

- There is one mapped Precambrian fault in the 100 square mile review of the Itasca Landfill, which shows FSP of 0.01 to 0.03 over 25 years.
- There are 10 mapped Precambrian faults in the 100 square mile review of the Vortex SWD, which all show FSP of 0.00 over 25 years.
- FSP modeling through 25 years, with injection rates that are likely overestimated, shows little to no risk of potential fault slip in the areas of review.
- These areas present little to no risk for injection induced seismicity.

References

U.S. Geological Survey. "Faults." https://earthquake.usgs.gov/hazards/qfaults/ (Accessed December 18, 2019)

U.S. Geological Survey. “Geologic Database of Texas”, 2014-02-01. Web. (Accessed December 18, 2019)

Ruppel, S. C., R. H. Jones, C. L. Breton, and J. A. Kane, 2005, “Preparation of Maps Depicting Geothermal Gradient and Precambrian Structure in the Permian Basin”: USGS Order no. 04CRSA0834 and Requisition no. 04CRPR01474.

Texas RRC. “Public GIS Viewer.” https://www.rrc.state.tx.us/about-us/resource-center/research/gis-viewers/ (Accessed January 3, 2020)

Snee, Jens-Erik Lund, and Mark D. Zoback. 2018. “State of Stress in the Permian Basin, Texas and New Mexico: Implications for Induced Seismicity.” *The Leading Edge* 37, no. 2 (February 2018): 127-34.

Hennings, Peter H., Jens-Erik Lund Snee, Johnathon L. Osmond, Heather R. Deshon, Robin Dommisse, Elizabeth Horne, Casee Lemons, and Mark D. Zoback. “Injection-Induced Seismicity and Fault-Slip Potential in the Fort Worth Basin, Texas.” Bulletin of the Seismological Society of America 109, no. 5 (2019): 1615–34. https://doi.org/10.1785/0120190017.

Appendix B

Vortex SWD Estimated Class I Conversion and Operational Costs

VORTEX WELL – CLASS I REPLACE TUBING AND PACKER	
SERVICES	**COST ESTIMATE**
Service Rig at $6,500 a day x 6 days	$39,000
Replacement of 4-1/2" Tubing with New Coated Tubing	$130,000
New Packer and Tool Man/Pump Truck/Corrosion Inhibitor – Internal MIT	$40,000
Power Tongs and Telehandler for Running Tubing	$7,000
Port-a-John	$500
Misc. Costs – Freshwater, Trucking, Etc.	$10,000
ALL Consulting – Oversight & Expenses	$30,000
Additional Perforating	$10,000
ESTIMATED COSTS	$266,500
ALL OVERSIGHT GENERAL CONTRACTOR – 15%	$39,975
15% CONTINGENCY	$39,975
TOTAL ESTIMATED COSTS	**$346,450**

VORTEX WELL – CLASS I MECHANICAL INTEGRITY TESTING	
Casing Hole Logging/Pump Truck – External MIT Testing	$50,000
Injectivity/Pressure Fall-Off Testing/Pump Truck/Gauges	$75,000
ESTIMATED COSTS	$125,000
ALL OVERSIGHT GENERAL CONTRACTOR – 15%	$18,750
15% CONTINGENCY	$18,750
TOTAL ESTIMATED COSTS	**$162,500**

VORTEX WELL – CLASS II SURFACE FACILITY CONVERSION TO CLASS I	
SERVICES	**COST ESTIMATE**
ALL Consulting – Construction Oversight & Expenses	$55,000
Roustabout and Plumbing	$50,000
Additional Lighting for 24/7 Operations	$30,000
Piping, Fittings, and Valves	$50,000
Continuous Digital SCADA Monitoring System	$70,000
Filter Pods and Filter Media	$55,000
Designs, Stamped Plans, and Permits	$40,000
Pressure Shut-off Switches and Alarms	$15,000
Manlift and Other Equipment	$10,000
ESTIMATED COSTS	$375,000
ALL OVERSIGHT GENERAL CONTRACTOR – 15%	$56,250
15% CONTINGENCY	$56,250
TOTAL ESTIMATED COSTS	**$487,500**

VORTEX WELL – CLASS I ANNUAL OPERATIONAL COSTS	
SERVICES	**COST ESTIMATE**
Manned Operation – 24/7 – 365 days	$210,000
Power and Other Services	$50,000
Equipment Repairs and/or Replacement	$150,000
Supplies – Filters, etc.	$50,000
Chemical Treatment	$250,000
Laboratory Testing and Regulatory Filings	$70,000
ESTIMATED COSTS	$780,000
15% CONTINGENCY	$117,000
TOTAL ESTIMATED COSTS	**$897,000**

ESTIMATED COSTS
REPUBLIC SERVICES - PERMIT TO DRILL (PTD) AND DRILL WELL
CLASS I NON-HAZARDOUS INJECTION WELL AT ITASCA LANDFILL, HILL COUNTY ,TEXAS
JANUARY 2020

Description				**Total**
Task 1 - Develop and Submit Application				**Estimated Cost**
Preparation and planning of the application for a Class I permit from TCEQ including all well construction, testing, planning, surveying, geological evaluation, and area of review for final submittal of application with fee to TCEQ.	ALL Consulting			$125,000 -$150,000
		Subtotal		**$125,000 -$150,000**
Task 2 - Prepare AFE and Obtain Quotes				**Estimated Cost**
ALL Consulting would prepare a detailed AFE with actual costs ad quotes from various contractors to perform the drilling, completion, and all testing requirements. This would include obtaining all W-9s and certificates of insurance from the various contractors for Republic Services.	ALL Consulting			$60,000-$75,000
		Subtotal		**$60,000-$75,000**
Task 3 - Drilling, Completion, and Testing				**Estimated Cost**
ALL would provide complete 24/7 oversight of the drilling, completion, testing, and submittal of all regulatory required documents to the TCEQ.	ALL Consulting			$250,000 -$300,000
		Subtotal		**$250,000-$300,000**
Task 4 - Contract/Labor Services	**Units**	**Costs**	**Markup**	**Estimated Cost**
Drilling Costs w/Moblization and Demob	1	$1,000,000	1	$1,000,000
Cementing Costs and Equipment	1	$150,000	1	$150,000
Wellhead and Equipment Costs	1	$125,000	1	$125,000
All Casing Costs	1	$600,000	1	$600,000
Drill Bits	1	$80,000	1	$80,000
Location Building and Reclamation Costs	1	$55,000	1	$55,000
Logging Costs (Mud Logging & Geophysical)	1	$175,000	1	$175,000
Drill Stem Testing and Fluid Analysis	1	$100,000	1	$100,000
Power Tongs and Casing Crews	1	$40,000	1	$40,000
Misc. Equipment, Water, KCL, and Fuel	1	$125,000	1	$125,000
Water Hauling, Frac Tanks, Disposal Costs	1	$60,000	1	$60,000
Injectivity Testing and Analysis	1	$100,000	1	$100,000
Consulting Drilling Engineer	1	$40,000	1	$40,000
Welding	1	$10,000	1	$10,000
Tubing, Packer and Perform MIT	1	$200,000	1	$200,000
Mud Program	1	$100,000	1	$100,000
		Contract Labor Total		**$2,960,000**
		Contingency (15%)		**$444,000**
		PROJECT SUBTOTAL		**$3,404,000**

APPENDIX

V-3 Logs of Wells Used to Construct Cross-Sections

APPENDIX V-2

WELL LOGS USED TO CONSTRUCT THE CROSS-SECTIONS

NORTH – SOUTH

JW Operating Co.
Dan Parker No. 1
API No. 42-251-301810000

JW Operating Co.
Padgett No. 1
API No. 42-217-303640000

Blackbeard Operating LLC
Eden No. 1H
API No. 42-217-306940000

WEST – EAST

Eagleridge Operating LLC
P Hook 690 No. 7V
API No. 42-217-304310000

Hunt Oil Co.
EW Wright No. 1
API No. 42-217-00017

Blackbeard Operating LLC
Boswell No. 1H
API No. 42-217-305530000

Mobil Oil Co.
EA Cockerham No. 1
API No. 42-139-300010000

Lasco Inc
RS Lesage No. 1
API No. 42-139-000630000

42-139-00063 ELLIS
LESCO INC
000001 LE SAGE R S
TD: 2898 ELEV : 722 DF
6mi NW/Italy

File No. 03-2874

SCHLUMBERGER
WELL SURVEYING CORPORATION

Location of Well

Elevation: D.F. 723'
K.B.:
or G.L.:

COMPANY: LESCO, INC.
WELL: R. S. LE SAGE # 1
FIELD: WILDCAT
LOCATION: HARRISON
COUNTY: ELLIS
STATE: TEXAS
FILING No. EN-188

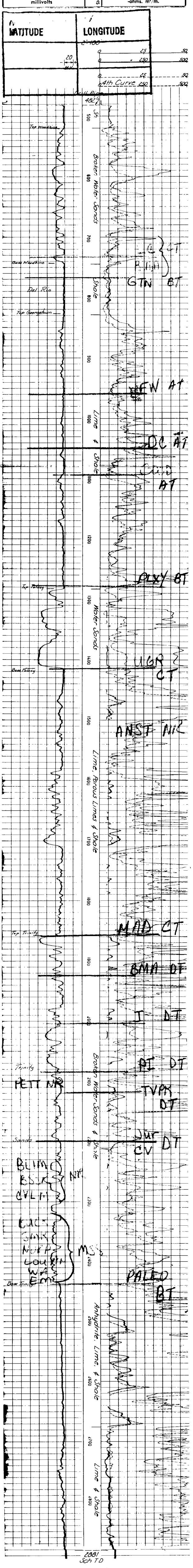
COUNTY: ELLIS
FIELD OR LOCATION: WILDCAT
WELL: R.S. LE SAGE #1
COMPANY: LESCO, INC.

RUN NO.	1				
Date	9/7/44				
First Reading	2881				
Last Reading	482				
Footage Measured	2399				
Csg Shoe Schlum	—				
Csg Shoe Driller	—				
Max. Depth Reached	2881				
Bottom Driller	2898				
Depth Datum	MEAS. FROM TOP OF ROTARY				
Mud Nature	BAR. & ACU.				
" Density	10.2				
" Viscosity	40				
" Resistivity	3.4@80 °F	@ °F	@ °F	@ °F	@ °F
" Resistivity BHT	@ °F	@ °F	@ °F	@ °F	@ °F
" pH	@ °F	@ °F	@ °F	@ °F	@ °F
" Water Loss	CC/30 Min.	CC/30 Min.	CC/30 Min.	CC/30 Min.	CC/30 Min.
Maximum Temp. °F					
Bit Size	8 3/4				
Spacings — AM	18"				
A					
AO	13"				
E.S. Rig Time					
Truck No.					
Recorded By	W.A. EICKMEYER				
Witnessed By					

REMARKS:

GCS

SPONTANEOUS-POTENTIAL millivolts	DEPTHS	RESISTIVITY -ohms. m²/m.



Lesco, Inc.
LeSage #1
Wildcat
Ellis Co.

79
East Texas Photography Co.
P.O. Box 1
Tyler, Texas
No. 14-14-0000

Number of Run: 1

Date: MAY 5, 1964

Company: SUN OIL CO.
Well: S. BLACK ET AL
Field: SANDERSON
County: BROWN State: TEXAS
Location: 330' SOUTH, 330' WEST
County: BROWN
State: TEXAS
Permanent Datum: GROUND LEVEL
Elevation: 1500
Log Measured From: 10 FT. ABOVE PERM. DATUM
Drilling Measured From: GROUND LEVEL
Elevation: 1500

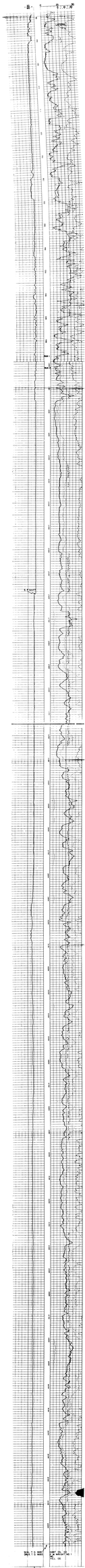
Run No.	1		
Date	5-5-64		
Time Started	1400		
Time Finished	1500		
Total Depth	2410		
Depth Logged	2410		
Depth Reached	2410		
Bottom Log Interval	2410		
Top Log Interval	2400		
Casing Size	8 5/8"		
Casing Depth	2400		
Type Fluid	WATER		
Density	8.4		
Viscosity	28		
Fluid Level	FULL		
Max. Rec. Temp.	90		
Equipment Number	1		
Location	14		
Recorded By	J. WEST		
Witnessed By	J. WEST		

Type Log: ES

Run No. 1

REMARKS

SELF-POTENTIAL	5	RESISTIVITY
100 mv/cm		20 ohm. m/cm



251 30181 ID: 208368 ①

HALLIBURTON EXCELL 2000

DUAL INDUCTION LOG

COMPANY J.W. OPERATING COMPANY
WELL DAN PARKER #1
FIELD WILDCAT
COUNTY JOHNSON STATE TEXAS

COMPANY	J.W. OPERATING COMPANY
WELL	DAN PARKER #1
FIELD	WILDCAT
COUNTY	JOHNSON D-05
STATE	TEXAS
API No.	42-251-30181
Location	2128' FSWL & 428' FSEL OF THE W. EASTMAN SURVEY ABS: 248
Other Services	DIL SDL/DSN EMI
Sect / Twp / Rge	
Permanent Datum	GROUND LEVEL Elev 641
Log measured from	KB 12 ft. above perm. datum
Drilling measured from	KELLY BUSHING
Elev.: K.B.	653
D.F.	652
G.L.	641

Date	25 MAY 04			
Run No.	ONE			
Depth - Driller	8884			
Depth - Logger	8865			
Bottom - Logged Interval	8853			
Top - Logged Interval	1868			
Casing - Driller	8 5/8 @ 1872	@	@	@
Casing - Logger	1868			
Bit Size	7 7/8 INCH			
Type Fluid in Hole	GEL CHEM			
Dens. | Visc.	9.5 | 111.0	|	|	|
Ph | Fluid Loss	9.5 | 6.4	|	|	|
Source of Sample	FLOWLINE			
Rm @ Meas. Temp.	1.62 @ 70 F	@	@	@
Rmf @ Meas. Temp.	1.30 @ 70 F	@	@	@
Rmc @ Meas. Temp.	2.30 @ 70 F	@	@	@
Source Rmf | Rmc	MEAS | MEAS	|	|	|
Rm @ BHT	0.704 @ 170 F	@	@	@
Time Since Circ.	05/25 0700			
Time on Bottom	05/25 1530			
Max. Rec. Temp.	170 F @ TD	@	@	@
Equip. | Location	98622 | JKSBTX	|	|	|
Recorded By	NEWSOME			
Witnessed By	MR TORBETT	MR BLASS		

RECEIVED RRC OF TEXAS MAY 10 2007 AUSTIN, TX O&G

LOG REC'D RECORDS MAY 2007

12

— Fold Here

Service Ticket No.: 3025812 API Serial No.: 42-251-30181 PGM Version:

CHANGE IN MUD TYPE OR ADDITIONAL SAMPLES		
Date | Sample No.	|	|
Depth – Driller		
Type Fluid in Hole		
Dens. | Visc.	|	|
Ph | Fluid Loss	|	|
Source of Sample		
Rm @ Meas. Temp.	@	@
Rmf @ Meas. Temp.	@	@
Rmc @ Meas. Temp.	@	@
Source Rmf | Rmc	|	|
Rm @ BHT	@	@
Rmf @ BHT	@	@
Rmc @ BHT	@	@

RESISTIVITY SCALE CHANGES

Type Log	Depth	Scale Up Hole	Scale Down Hole

RESISTIVITY EQUIPMENT DATA

Run No.	Tool Type & No.	Pad Type	Tool Pos.	Other
ONE	DIND I409	NONE	1.5IN SO	NA
ONE	MICRO I104M601	BLACK	CALIPER	NA
ONE	SGRD 108964	NONE	1.5IN SO	NA

EQUIPMENT DATA

GAMMA		ACOUSTIC		DENSITY		NEUTRON	
Run No.	ONE	Run No.		Run No.	ONE	Run No.	ONE
Serial No.	108611	Serial No.		Serial No.	104I601M	Serial No.	108764
Model No.	NGRT_A	Model No.		Model No.	SDL_DA	Model No.	DSN_II
Diameter	3.625	No. of Cent.		Diameter	4.5	Diameter	3.625
Detector Model No.	A102	Spacing		Log Type	GAM/GAM	Log Type	NEU/NEU
Type	SCINT			Source Type	Cs 137	Source Type	Am241Be
Length	4"	LSA [Y / N]		Serial No.	2659 GW	Serial No.	DSN 7
Distance to Source	NA	FWDA [Y / N]		Strength	1.5 Ci	Strength	18.5 Ci

LOGGING DATA

GENERAL				GAMMA		ACOUSTIC			DENSITY			NEUTRON		
Run	Depth		Speed	Scale		Scale			Scale			Scale		
No.	From	To	Ft / Min	L	R	L	R	Matrix	L	R	Matrix	L	R	Matrix
ONE	8865	1868	REC	0	150				30%	-10%	2.71	30%	-10%	LIME

DIRECTIONAL INFORMATION

Maximum Deviation deg. @ KOP

Remarks:
ALL TOOLS RAN IN COMBINATION, SEE TRAILER FOR CONFIGURATION AND FIRST READINGS.
ANNULAR HOLE VOLUME CALCUALTED FOR 5.5 INCH CASING
MANUAL SP SHIFT @ 8030
CALIPER CLOSED @ 7798 DUE TO HOLE CONDITIONS (TIGHT PULLS)

RIG: TEXAS-WYOMING #8
TODAYS CREW: NEWSOME, HICKS, J. TANNER
THANK YOU FOR USING HALLIBURTON ENERGY SERVICES. JACKSBORO, TX 940.567.6418

HALLIBURTON DOES NOT GUARANTEE THE ACCURACY OF ANY INTERPRETATION OF THE LOG DATA, CONVERSION OF LOG DATA TO PHYSICAL ROCK PARAMETERS OR RECOMMENDATIONS WHICH MAY BE GIVEN BY HALLIBURTON PERSONNEL OR WHICH APPEAR ON THE LOG OR IN ANY OTHER FORM. ANY USER OF SUCH DATA, INTERPRETATIONS, CONVERSIONS, OR RECOMMENDATIONS AGREES THAT HALLIBURTON IS NOT RESPONSIBLE EXCEPT WHERE DUE TO GROSS NEGLIGENCE OR WILLFUL MISCONDUCT, FOR ANY LOSS, DAMAGES, OR EXPENSES RESULTING FROM THE USE THEREOF.
HALLIBURTON

2 INCH MAIN LOG

HALLIBURTON
Version No: 5.5 | hc:3.0
Data File: dan_parker_1_r1.3.cls
Format File: DIL_2IN.spc
Plot Time: 2004-05-25 18:19:33
Log Time: 2004-05-25 15:28:06
Top Depth: 1850.00
Bottom Depth: 8887.00

GAMMA: 0 GAMMA 150
SP: -]20[+
1:600 FT.
DEEP COND: 1000 MMHO 0
DEEP RES: 0 OHMM 50
SHORT GUARD: 0 OHMM 50

SHORT GUARD: 0 OHMM 50
SP: -]20[+
DEEP RES: 0 OHMM 50
GAMMA: 0 GAMMA 150
1:600 FT.
DEEP COND: 1000 MMHO 0

HALLIBURTON
Version No: 5.5 | hc:3.0
Data File: dan_parker_1_r1.3.cls
Format File: DIL_2IN.spc
Plot Time: 2004-05-25 18:19:21
Log Time: 2004-05-25 15:28:06
Top Depth: 1850.00
Bottom Depth: 8887.00

2 INCH MAIN LOG

APPENDIX

V-4 2D Seismic Interpretation Report (Hill, 2023)

WSP

ITASCA PROJECT

HILL COUNTY, TEXAS

Seismic and Geology Report

26 OCTOBER 2023

Kevin B. Hill

Louisiana Licensed Professional Geoscientist # 475

Society of Independent Professional Earth Scientists - Certification #3583

President

Hill Geophysical Consulting

Suite 200

415 Texas Street

Shreveport, LA 71101 USA

Voice: 318.221-3329 Email: kevin@hillgeo.com

HILLGEO.COM

ITASCA PROJECT INFORMATION AND WORK FLOW

STUDY REQUIREMENTS: The reason for the study was to use well and seismic data to define the sub-surface of the Ellenberger formation for possible injection of fluids. The data must include all available well information and modern (reprocessed) seismic data. Mapping should include seismic integrated with sub-surface well data.

STUDY AREA: The study area is centered on the Wheeler Survey A-940 in Hill County, Texas.

MAP PROJECTION: The data in the project is in NAD 27 Texas Central 4203

WELL DATA: Wells locations and information was gathered from the TXRRC website within a 10 mile radius circle centered on A-940. Well logs were from the TXRRC and HillGeo's data base. Well locations were vetted using registered aerial photography.

SEISMIC DATA: A seismic data search was done using multiple seismic data brokers. Both 2d and 3D seismic was located over the area. All data was checked for quality and usefulness. The 3D seismic data over the area was broken into three different data sets that barely overlapped. The data were degraded by many skips due to surface and mineral non-permits. The 2d seismic data was collected by different companies at different times with different acquisition and processing parameters. The 2d data was determined to cover the study area adequately, was deemed be good and would be reprocessed to bring it all to a common modern processing state. Five lines were licensed for the project work.

SEISMIC PROCESSING: Dan Todd and Associates of Metairie, Louisiana. Data was pre-stack time migrated. A 800 foot datum was used, all lines were shifted to tie each other correctly, and the amplitudes were balanced to achieve the best average amplitude across the data sets.

INTERPRETATION: Well logs were correlated in the project area on the top and base of the Marble Falls, top and base Barnett, and top Ellenberger. The Viola/Simpson interval is present in every well log that penetrated the base Barnett and top Ellenberger in the study area and ranges from 54 feet in thickness in the southeast to over 150 in the northwest of. A synthetic seismogram was generated from a sonic log in a deep well that penetrated 50+ feet of Ellenberger. The well is less than 2000 feet from a seismic line. An excellent tie was made between the well's key formation tops and seismic reflectors.

MAPPING: Seismic events were found for the top Marble Falls and Barnett. The seismic times were converted to depth using the time/depth chart from the synthetic seismogram tie. Structure maps of the two horizons are made using a 800 foot datum which is close to the average surface elevation in the area. An isopach map of the Viola/Simpson (base Barnett to the top Ellenberger) interval was generated from well control.

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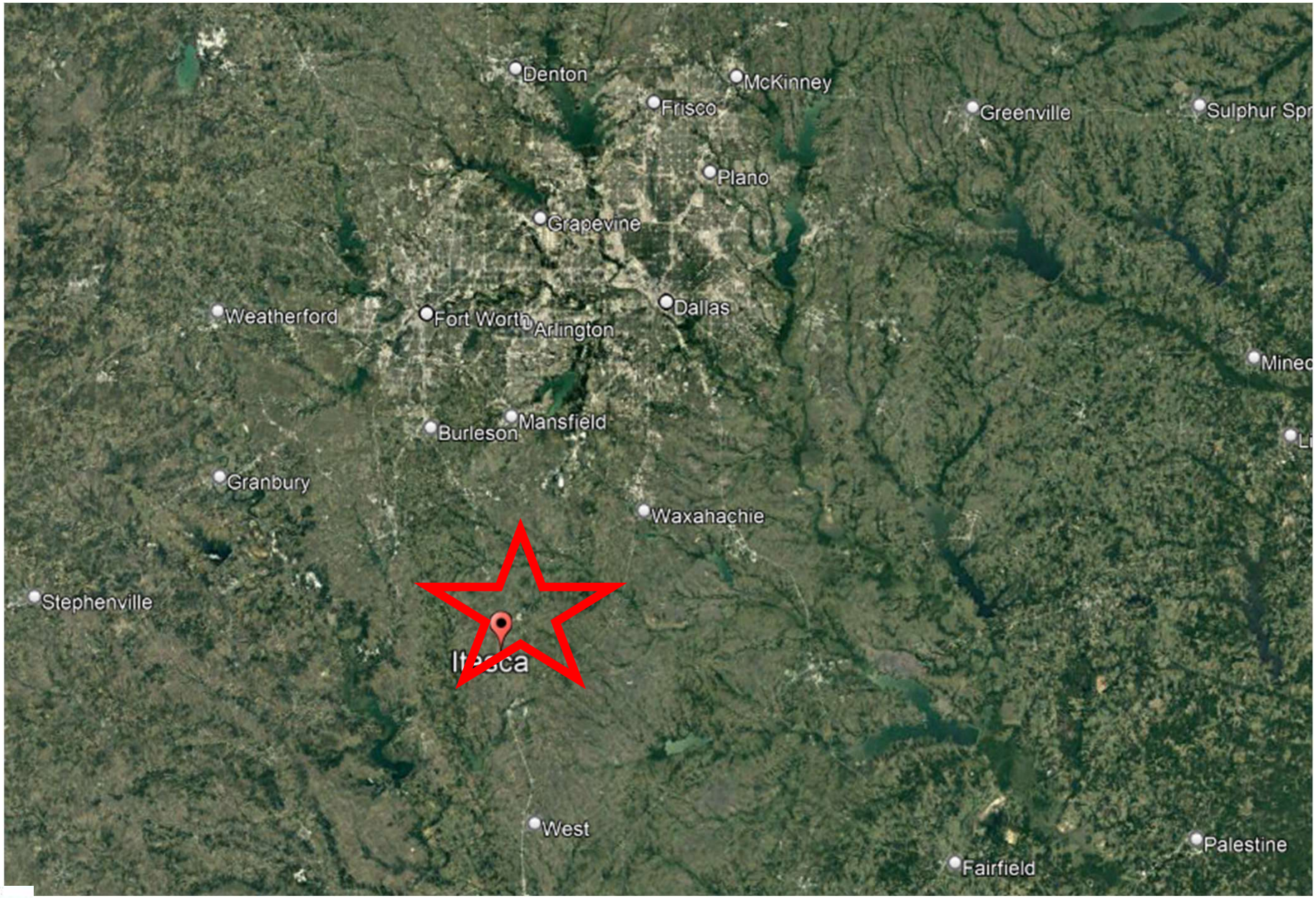
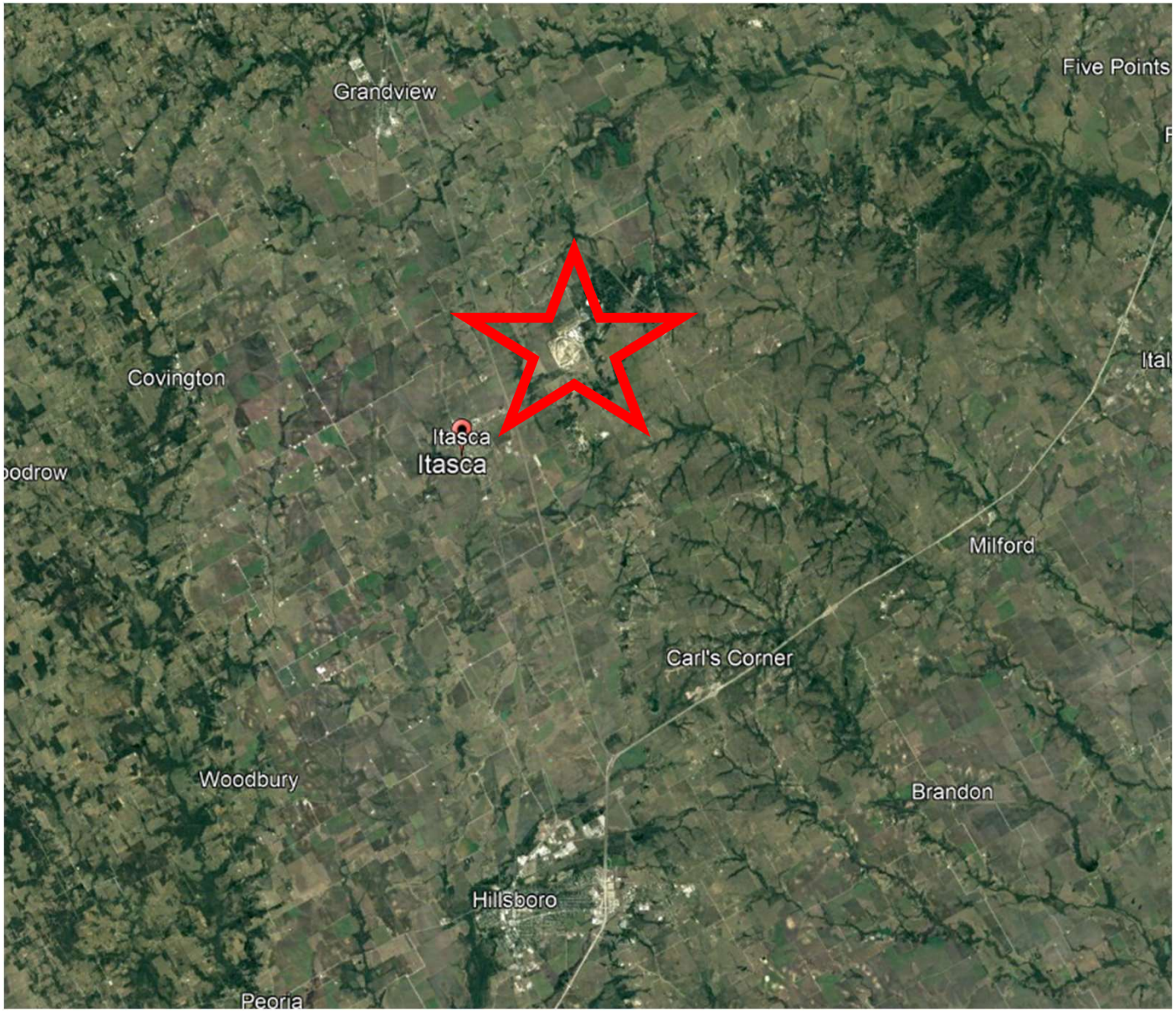
ITASCA PROJECT LOCATION ON GOOGLE EARTH



HILLGEO.COM

ITASCA PROJECT LOCATION ON GOOGLE EARTH



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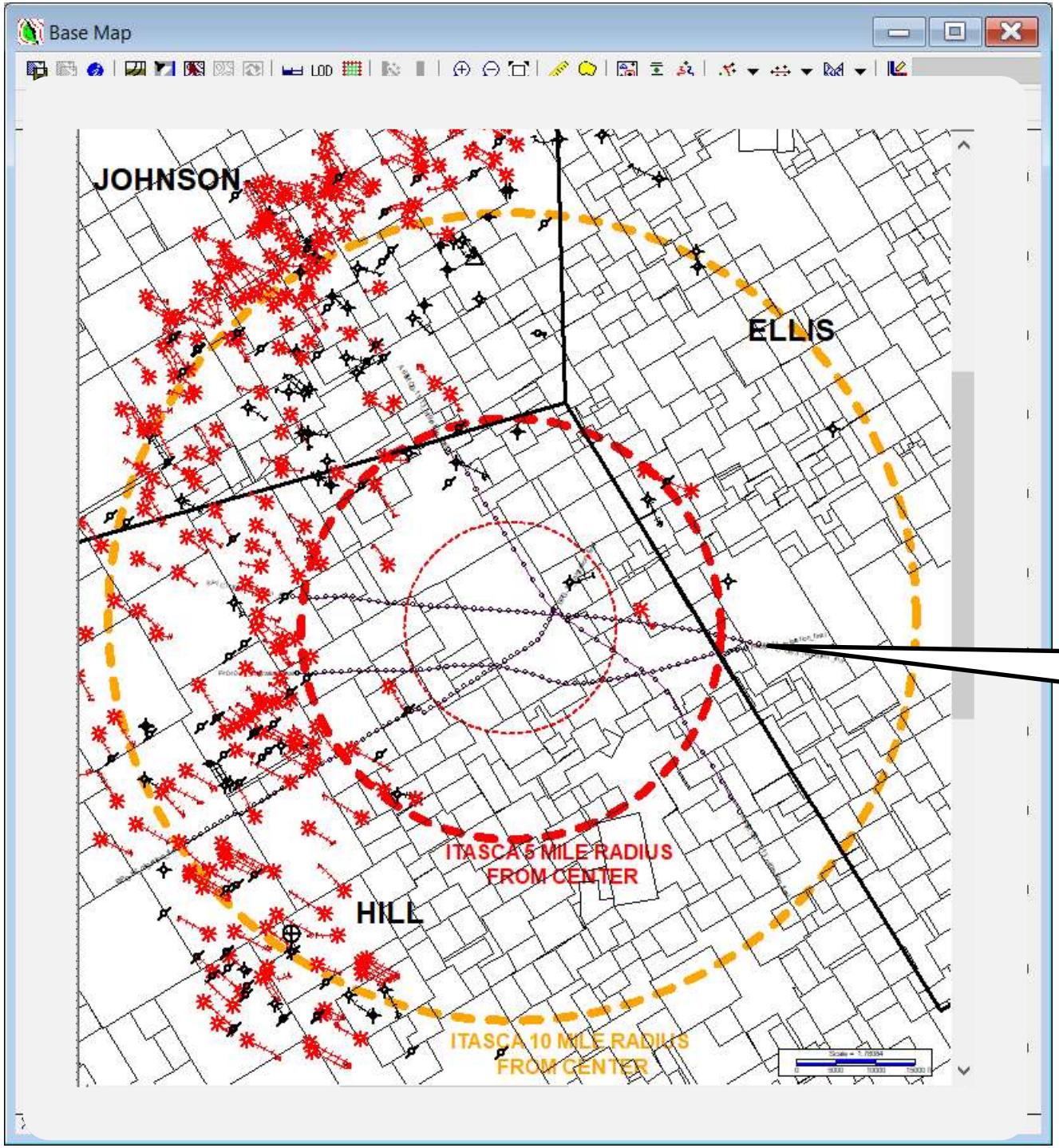
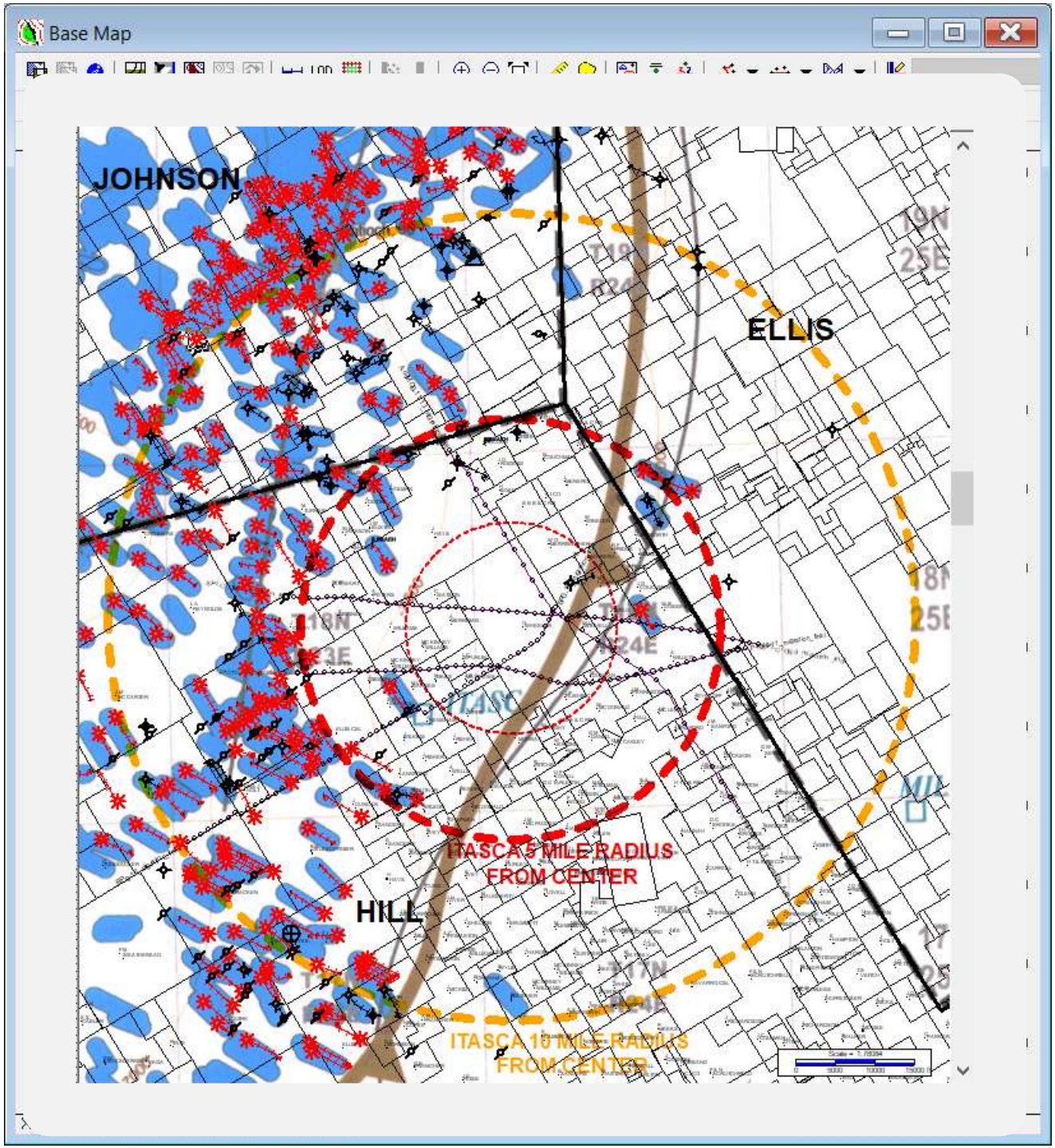
BASE MAP WITH ALL WELLS WITHIN THE STUDY AREA



2d seismic lines

HILLGEO.COM

GEOMAP® SHOWS BARNETT WELLS IN BLUE AND A LARGE FAULT



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This map is a general depiction of the current well information *only*.

GEOLOGIC and SEISMIC WORK FLOW

Geology: 386 well locations were found within the 10 mile study area. 142 wells had electric or MWD logs. The 142 wells had good points of correlation on the Marble Falls and Barnett shale. 25 well logs were found that penetrated the top of the Ellenberger formation. Many fewer wells are drilled within a 5 mile radius circle around the center of the study area. A deep disposal well (EOG #1 Gordon SWD – 13,100' MD) is located about 9 miles southwest of the center of the study area. This well logs shows many porous zones in the Ellenberger formation.

Seismic: A synthetic seismogram was generated from a sonic log in the DTE Gas Resources Inc. #7V Hooks P690 well API 42217304310000. The well is approximately 1900 feet north of line P4040-11. The well tie to the seismic is excellent. The seismic has a good reflector at the top Marble Falls and top Ellenberger. Reflections within the interval of the top Marble Falls to the top Ellenberger are not consistent, and well control is difficult to understand and correlate due to the wells going horizontal along this interval. The top Ellenberger is a very consistent reflector that was tied to well control. The reprocessed data by Dan Todd and Associates shows good reflectors that appear to match the structural dip seen in well control. There is less than 50 foot variation between the wells and seismic reflections when the Marble Falls and Ellenberger time values are converted to depth using the time/depth chart from the synthetic seismogram.

Structure Maps: All contour maps have a sub-sea datum. The well formation tops and seismic horizon reflectors for the Marble Falls, Barnett top and Ellenberger top were integrated using DDC. Contours were generated at 200 foot intervals. Minor hand smoothing was done. The structure map for the Barnett base was generated using the Barnett isopach and adding it to the Barnett top. The Pre-Cambrian granite map has the most uncertainty because only two well points were available to calculate a good velocity grid. The granite depth values could not be calculated from DDC. Therefore, the average velocity value calculated from depth/time (-8933f/s) was used to convert the time values to depth. All structure contour maps have been exported in Isomap Z-MAP Plus and DXF formats using NAD 27 Texas Central 4203 and shp files in NAD 27 Texas N Central 4202.

Isopach Maps: The isopach maps of the Marble Falls to the top of the Barnett and Ellenberger to Pre-Cambrian granite isopach was constructed by subtracting the formation tops and (gridded) contours for the respective horizons. The Barnett isopach was generated by subtracting the formation tops, contouring the well log values, observing the average thickness in the area of the seismic lines and adding the contoured thickness from wells to the seismic Barnett top, gridding the new Barnett base map and then subtracting the Barnett top and base maps. The Ellenberger isopach map was generated by gridding the contours of the Ellenberger top and Pre-Cambrian granite and subtracting the two grids. The contours were then hand smoothed.

Faulting: The seismic data shows a down-to-the-east fault across the southeast side of the study area. Faulting is not seen in well control, but formation tops appear to be a few hundred feet lower on the down-thrown side of the fault. The fault cuts into the shallow section and appears to stop at an unconformity around 3000 feet. The fault is interpreted to have about 200 feet displacement on the seismic data.

Conclusion: The reprocessed 2d seismic lines, when integrated with the well control, allows mapping of the top Ellenberger in the study area. The map shows a strong nose plunging to the southeast across the study area. A 200 foot fault is present on the southeast edge of the study area. The faulting puts the middle Barnett and Simpson/Viola section against the top 200 feet of Ellenberger.

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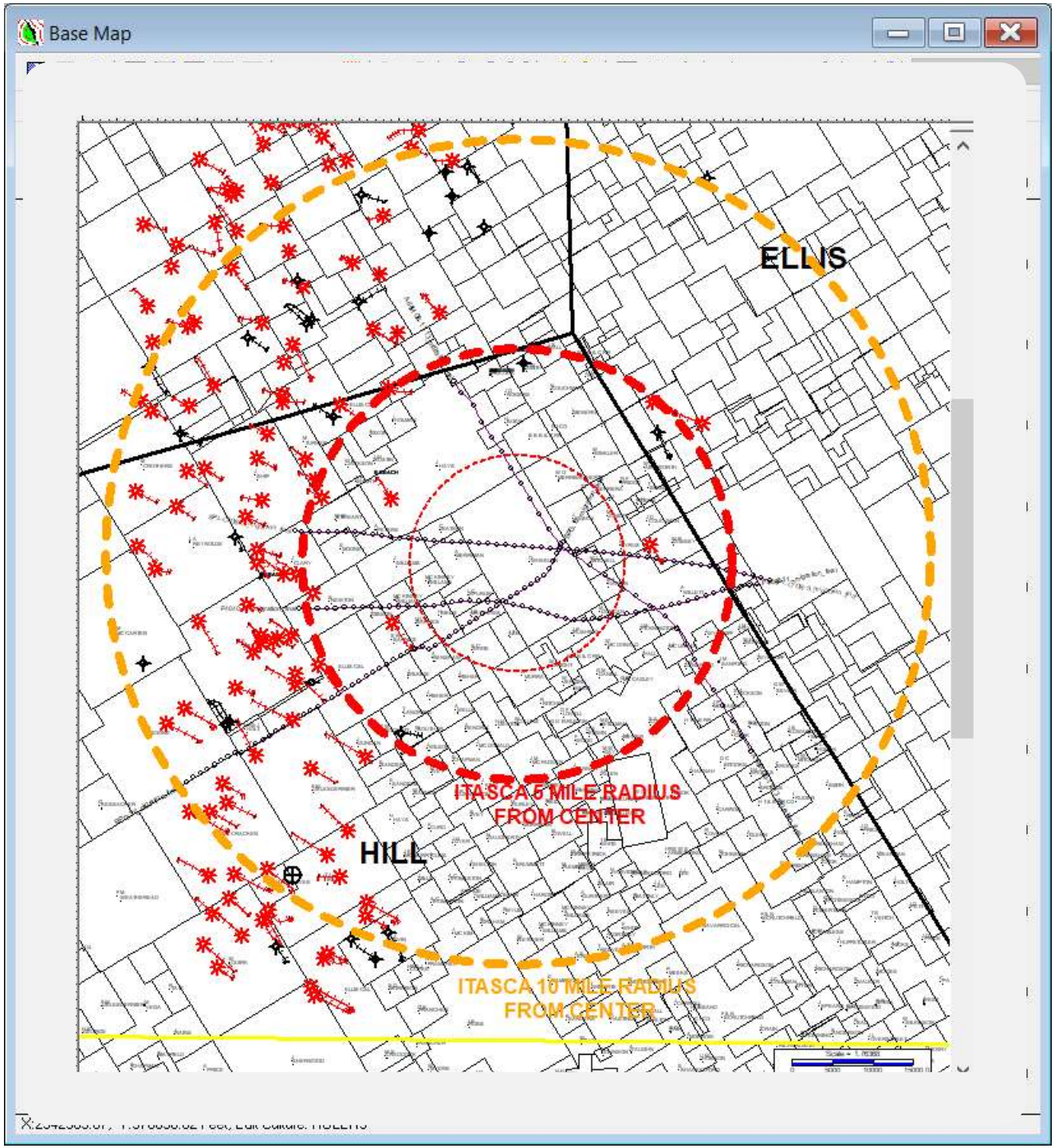
WELLS THAT PENETRATE THE BARNETT SHALE AND HAVE LOGS



142 wells have logs with good Barnett shale picks.

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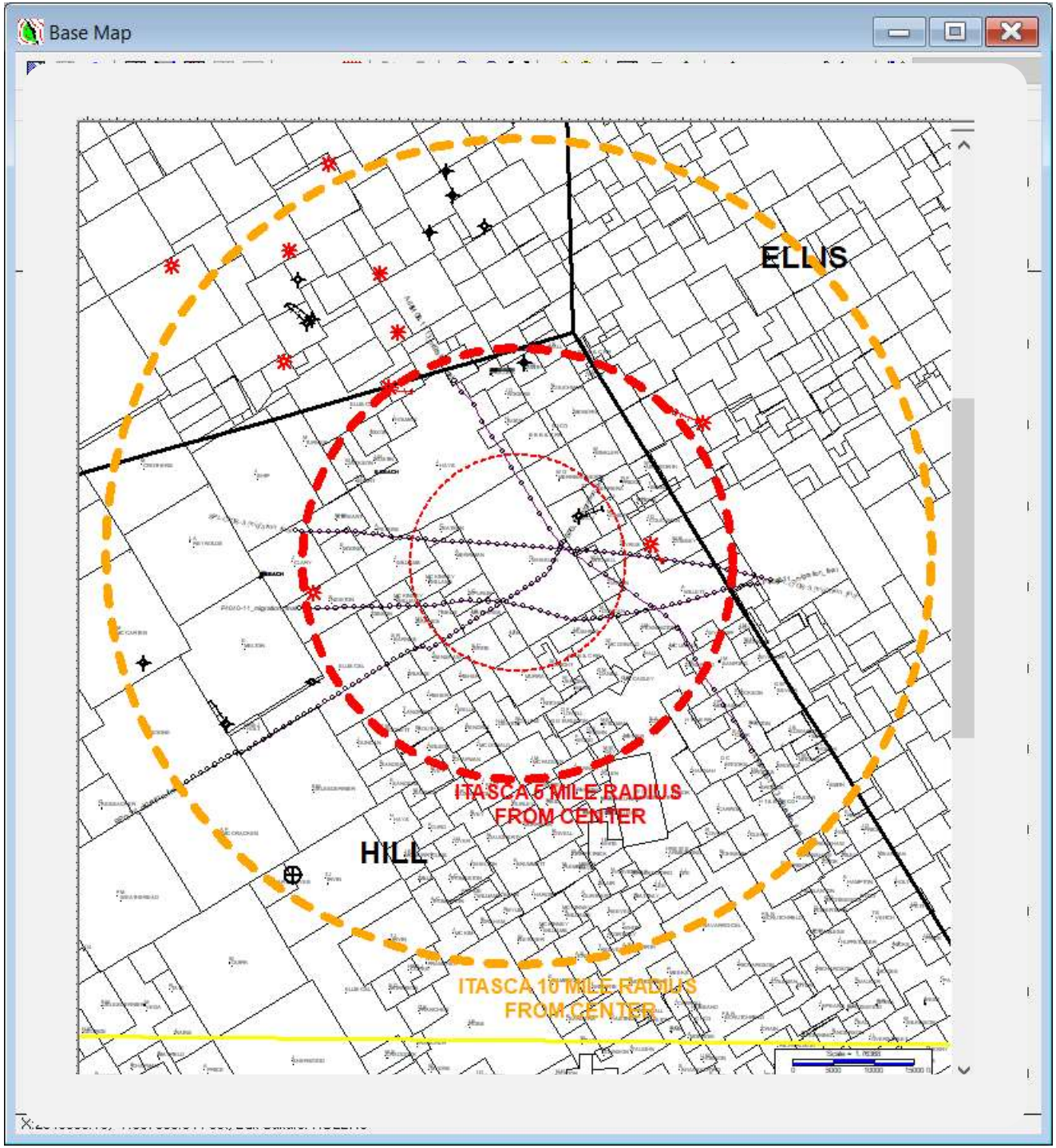
WELLS THAT PENETRATE THE ELLENBERGER AND HAVE LOGS



25 wells have logs with good top Ellenberger picks.

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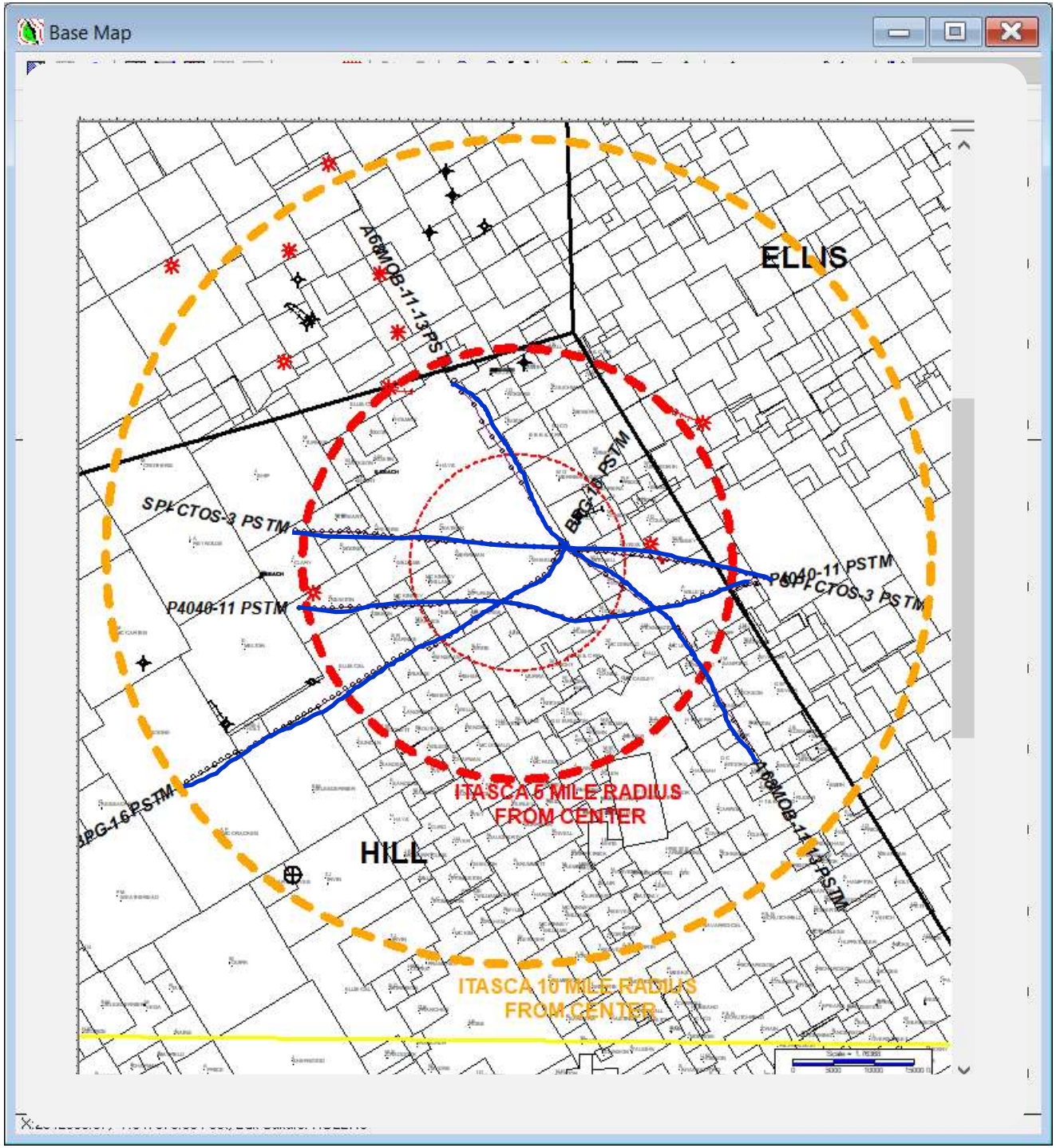
2d SEISMIC LINES WITH ELLENBERGER WELLS



The four seismic lines (blue) bisect the study area.

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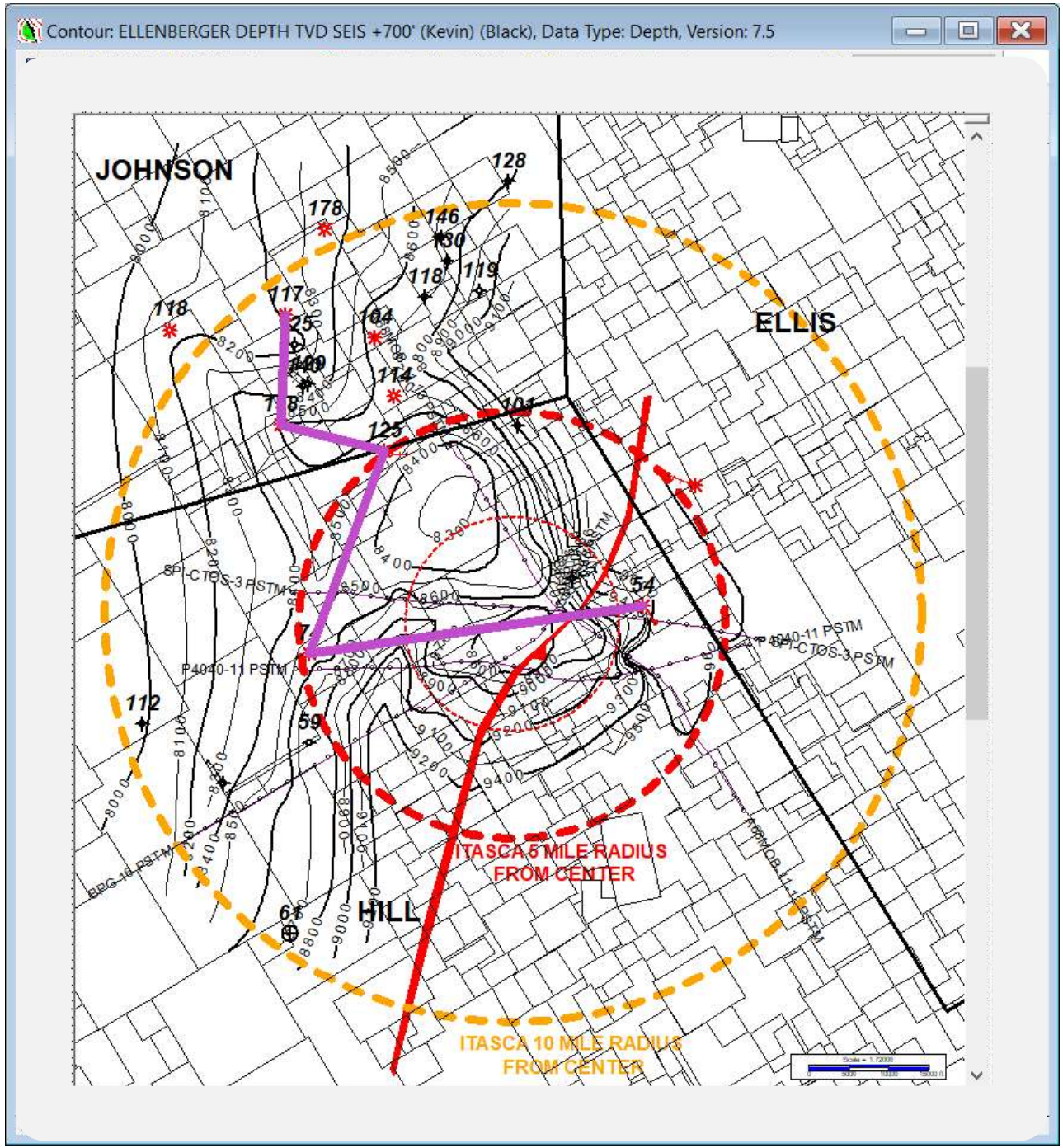
LINE OF CROSS-SECTION (purple) THROUGH WELLS THAT PENETRATE ELLENBERGER



The Simpson/Viola thickness is posted on the top Ellenberger map.

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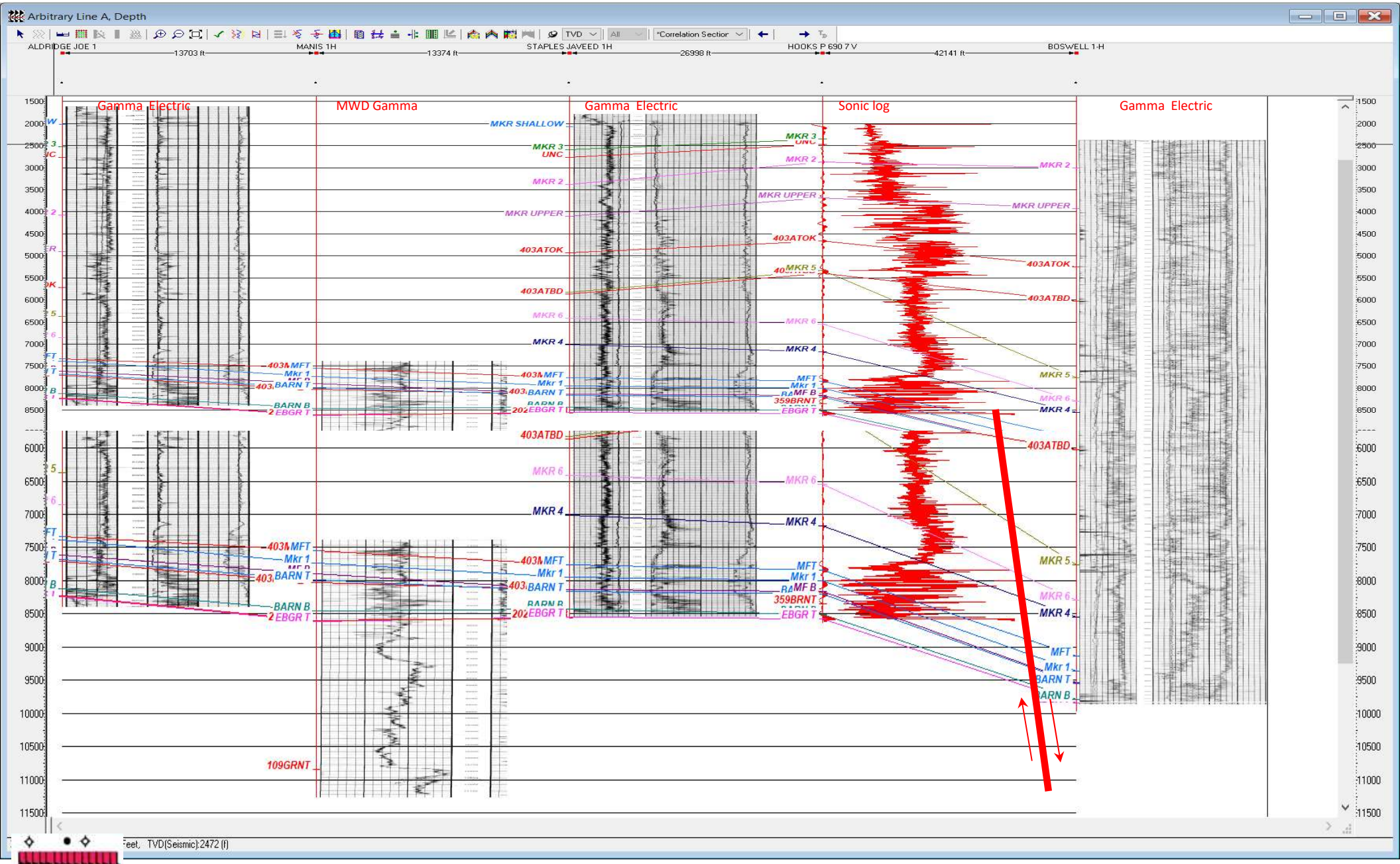
STRUCTURAL CROSS-SECTION (purple) THROUGH WELLS THAT PENETRATE ELLENBERGER



Different types of logs are displayed with the formation tops.

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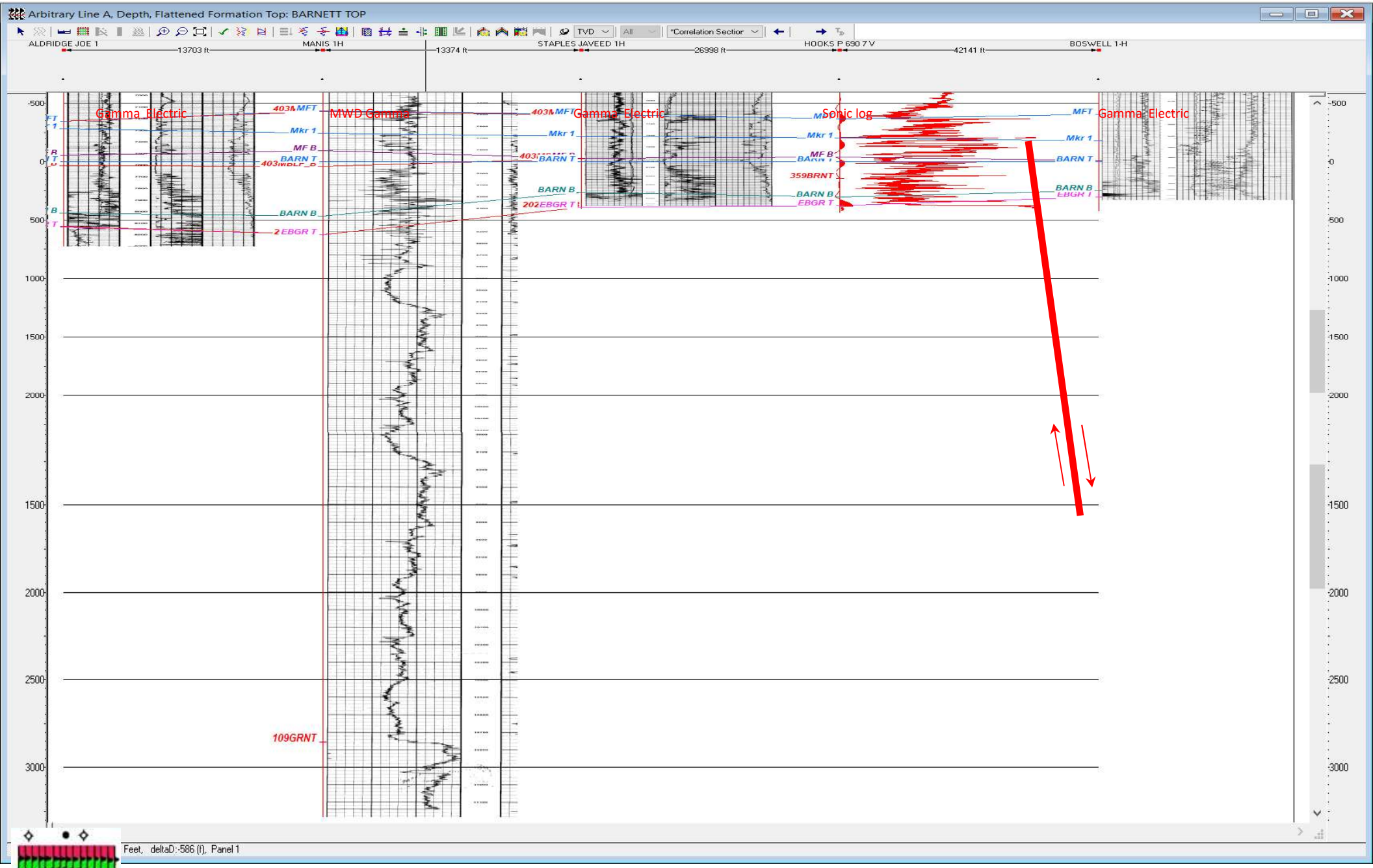
STRATIGRAPHIC CROSS-SECTION HUNG ON TOP BARNETT



The stratigraphic section shows the geologic section from the top Marble Falls down is very consistent thickness.

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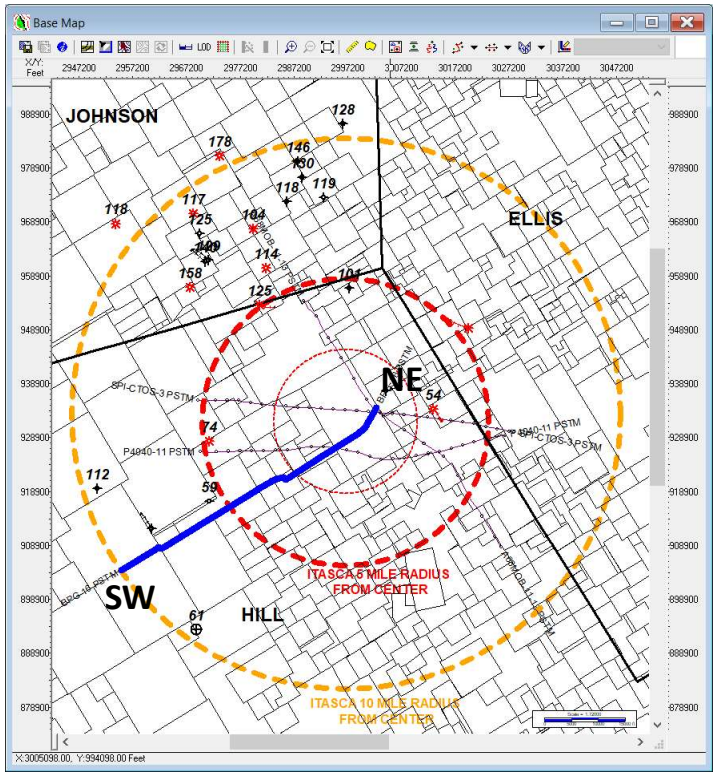
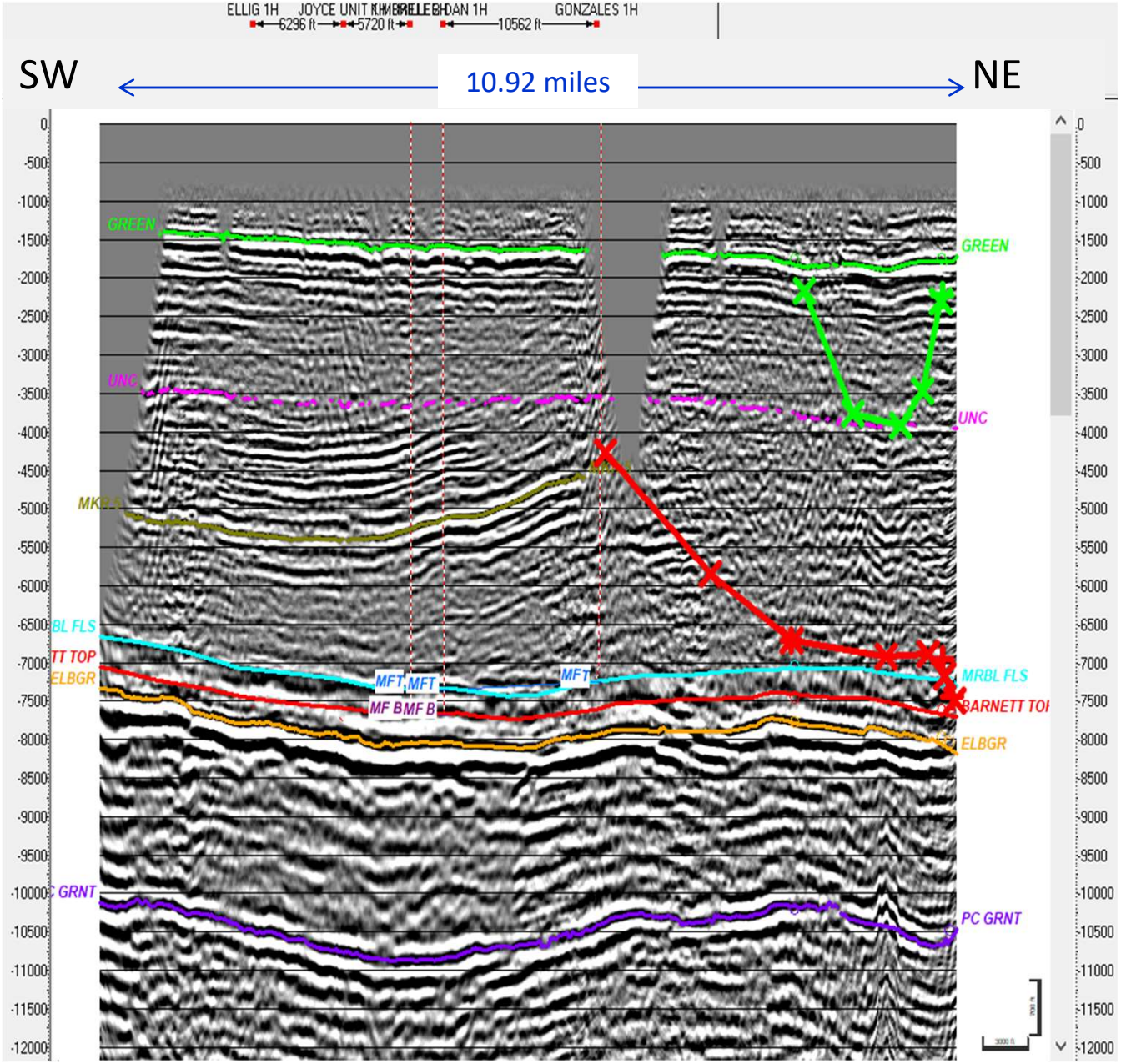
2d SEISMIC LINE BPG-16

Wells within 500 feet of the line are projected in to the line.





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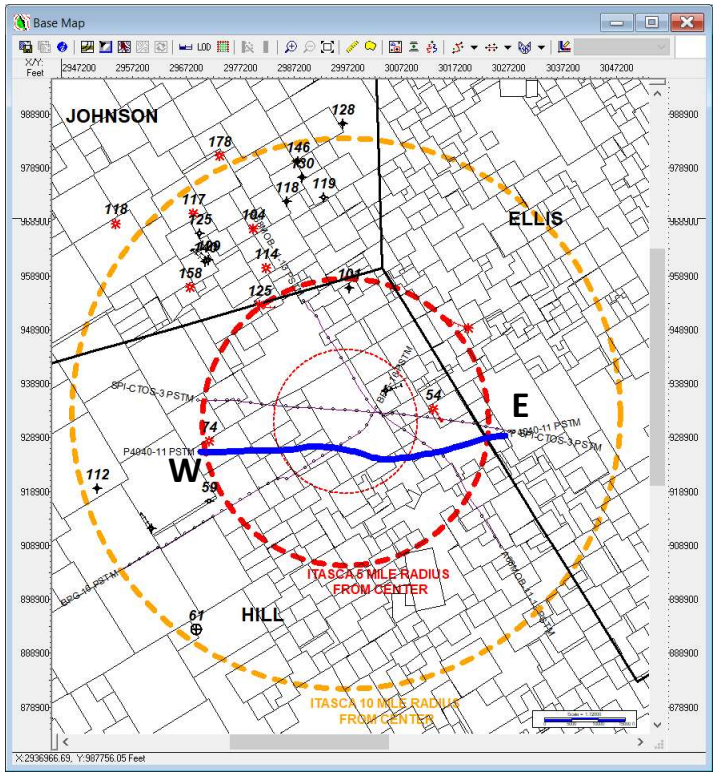
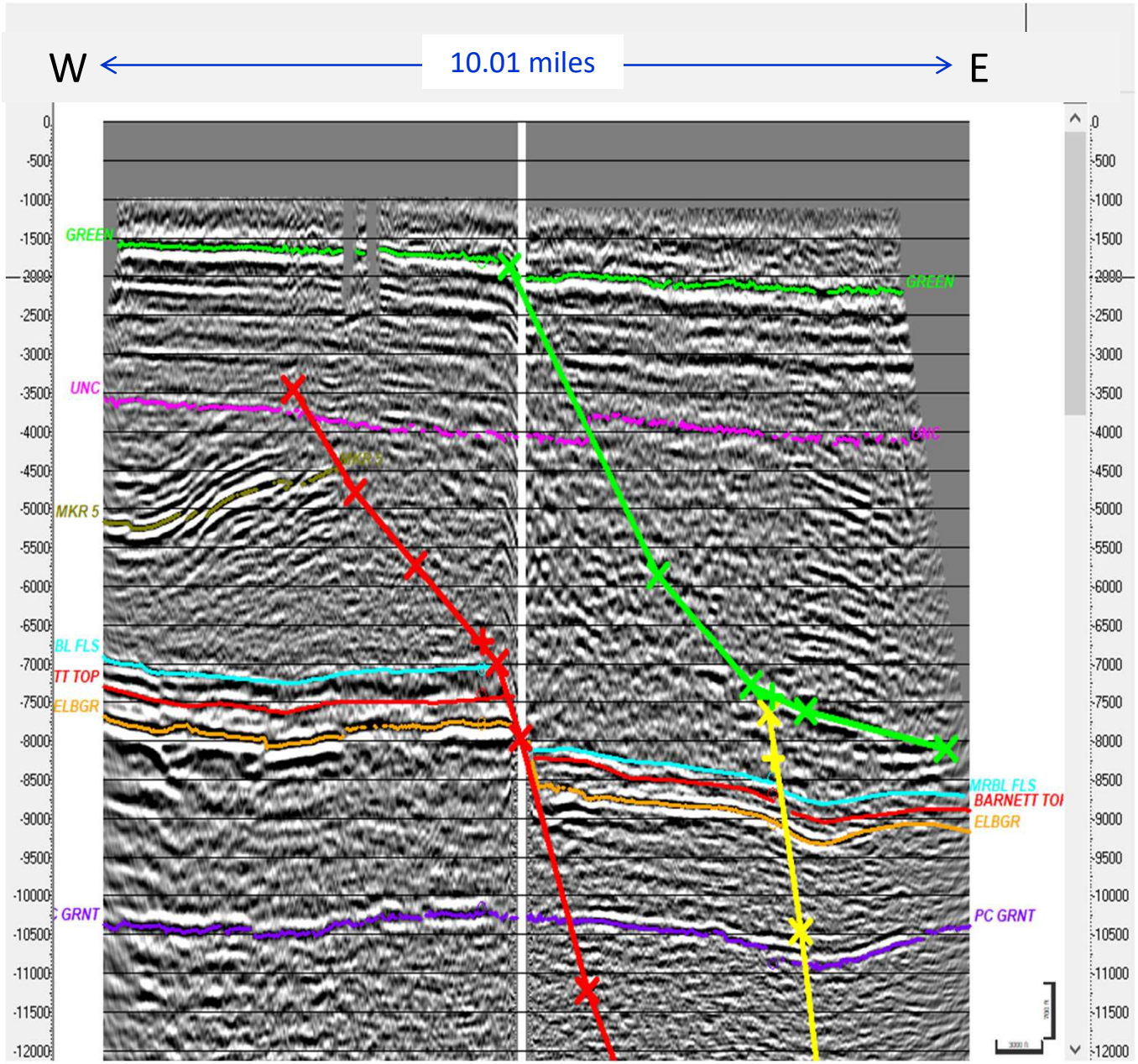
The data was reprocessed in April 2023 with pre-stack time migration, normalized amplitudes converted to depth using DDC.

2d SEISMIC LINE P4040-11





The data was reprocessed in April 2023 with pre-stack time migration, normalized amplitudes converted to depth using DDC.

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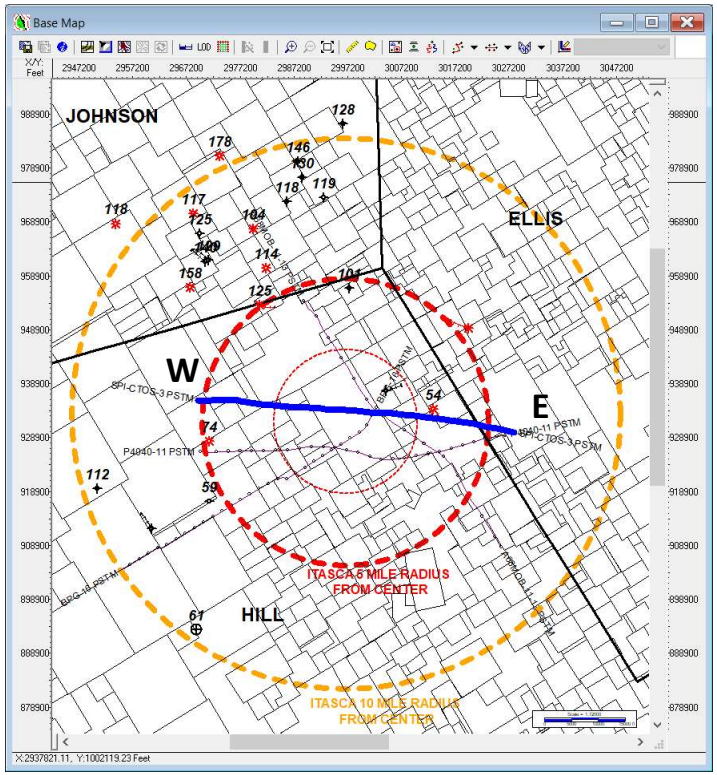
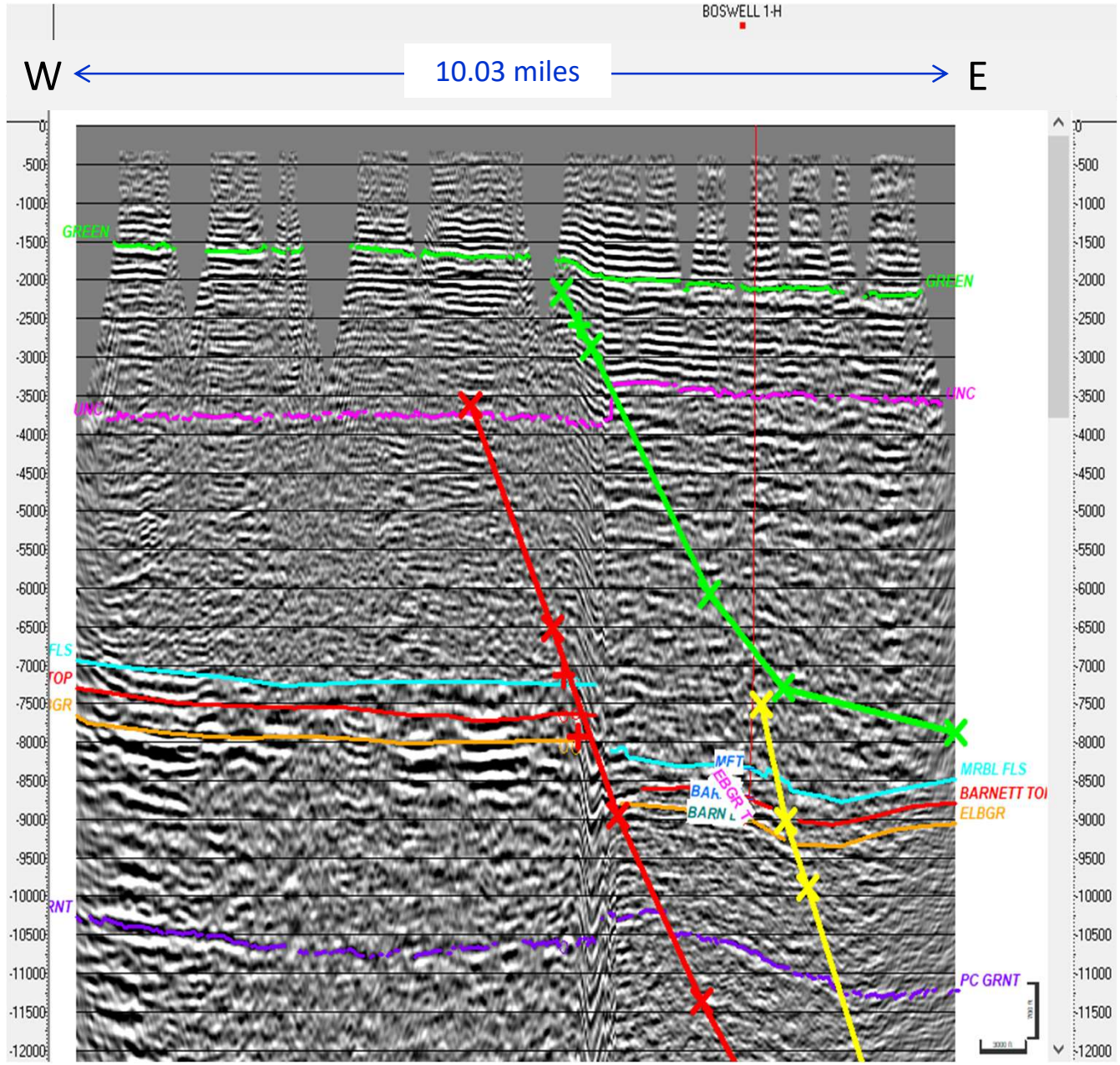
2d SEISMIC LINE SPI-CTOS-3

Wells within 500 feet of the line are projected in to the line.





The data was reprocessed in April 2023 with pre-stack time migration, normalized amplitudes converted to depth using DDC.

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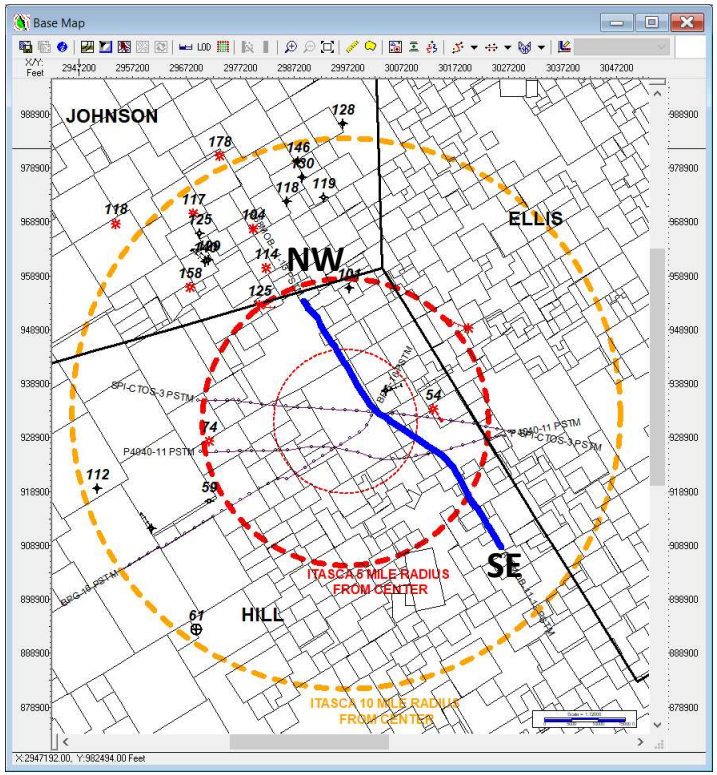
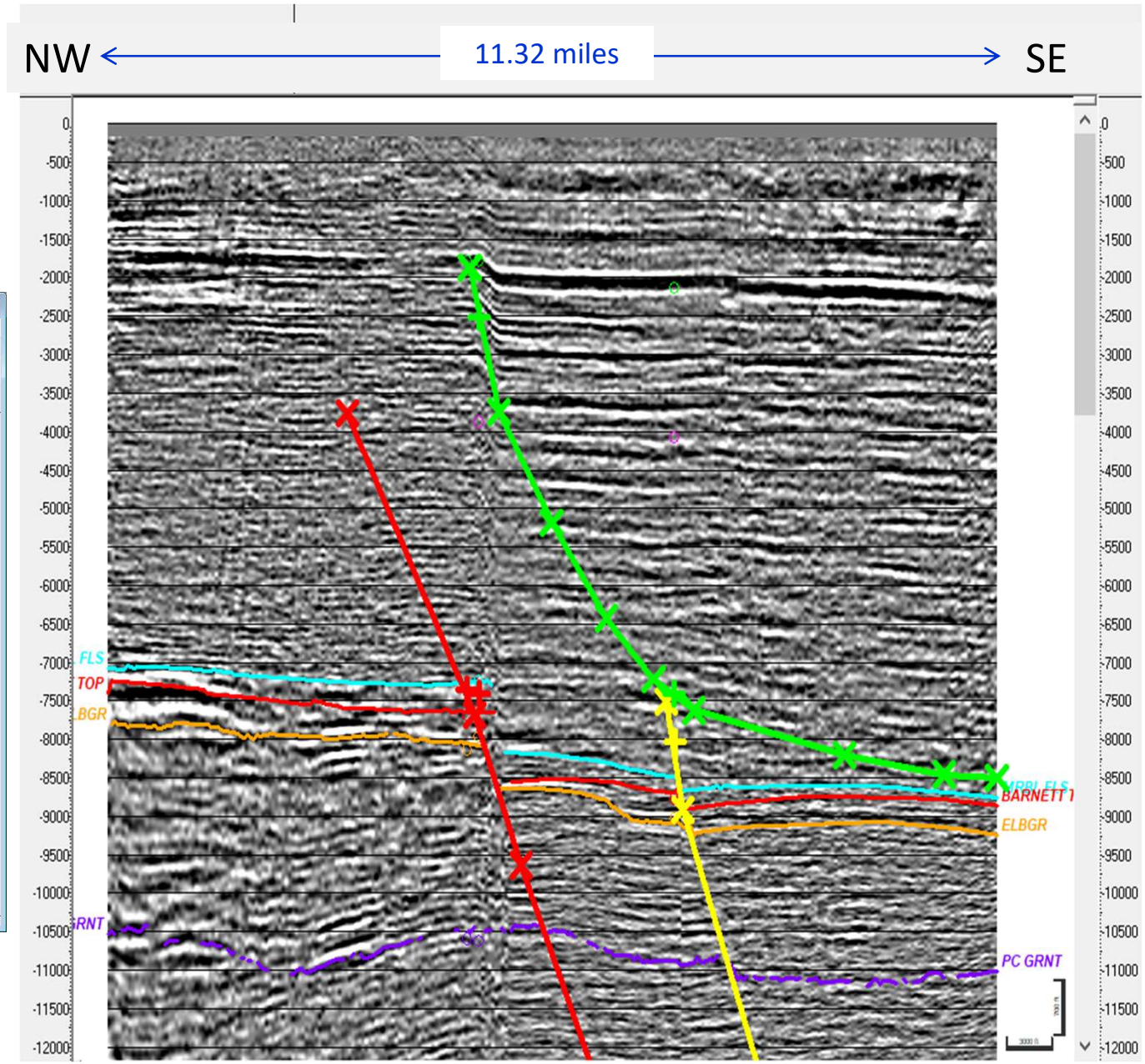
2d SEISMIC LINES A68MOB11-13 (Merged into one line)





The data was reprocessed in April 2023 with pre-stack time migration, normalized amplitudes converted to depth using DDC.

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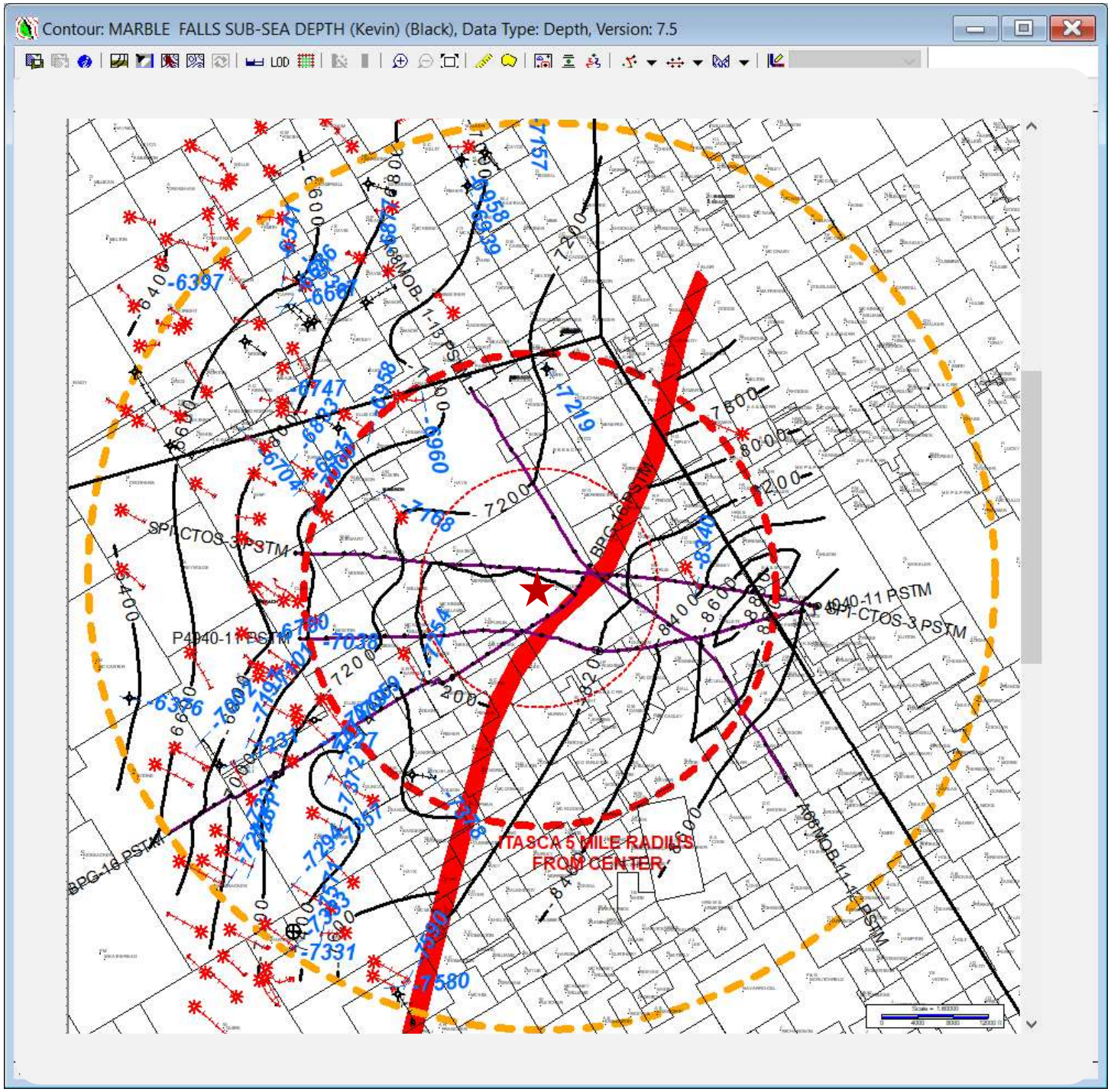
TOP MARBLE FALLS STRUCTURE MAP DATUM: SEA-LEVEL CI: 200’

All wells with raster logs turned on

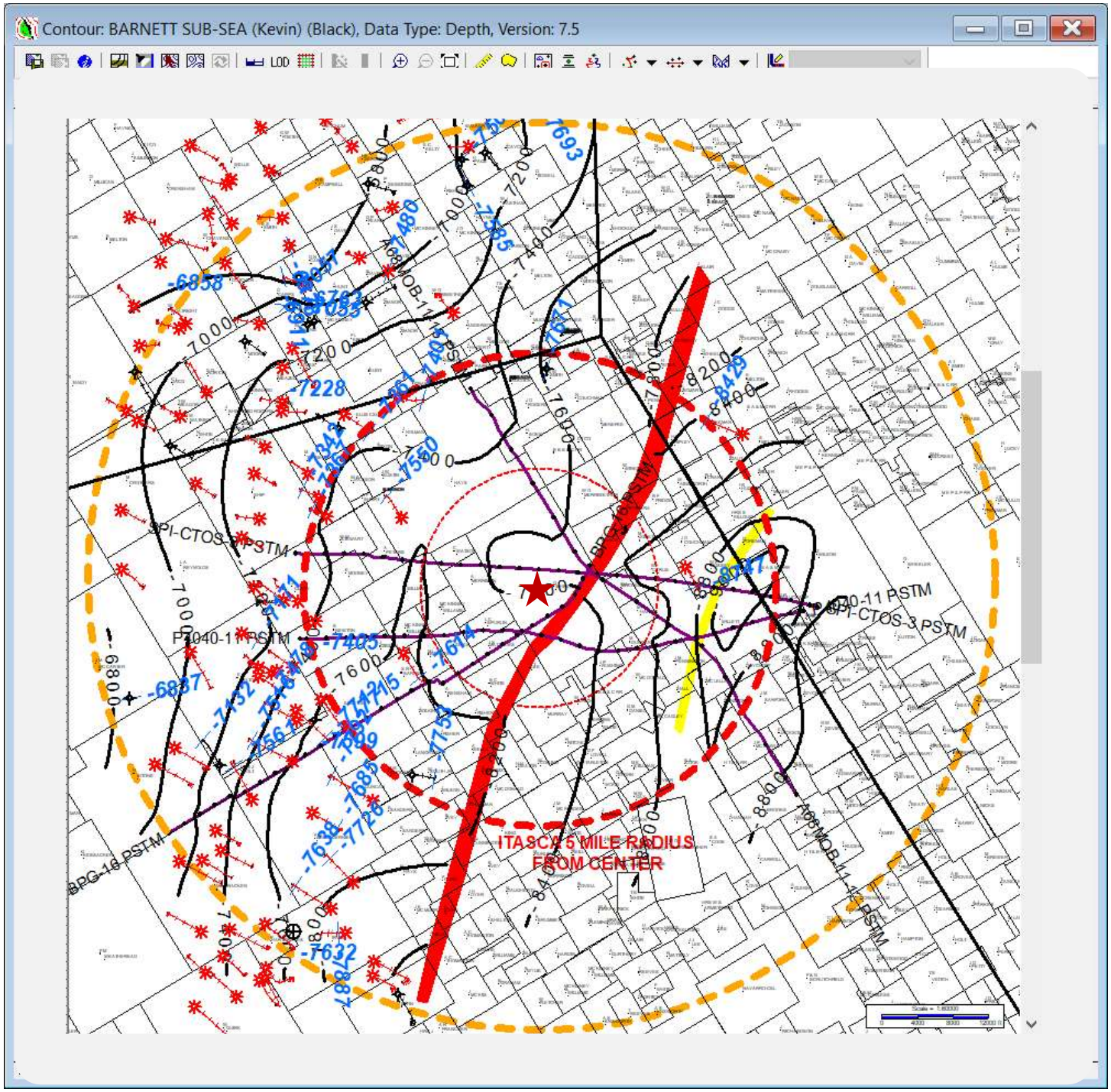


Seismic time converted to depth using wells and DDC.
Red is a down-to-the-east fault shown on the seismic data.

HILLGEO.COM

TOP BARNETT SHALE STRUCTURE MAP DATUM: SEA-LEVEL CI: 200’

All wells with raster logs turned on



Seismic time converted to depth using wells and DDC.
Red and Yellow are down-to-the-east faults shown on the seismic data.

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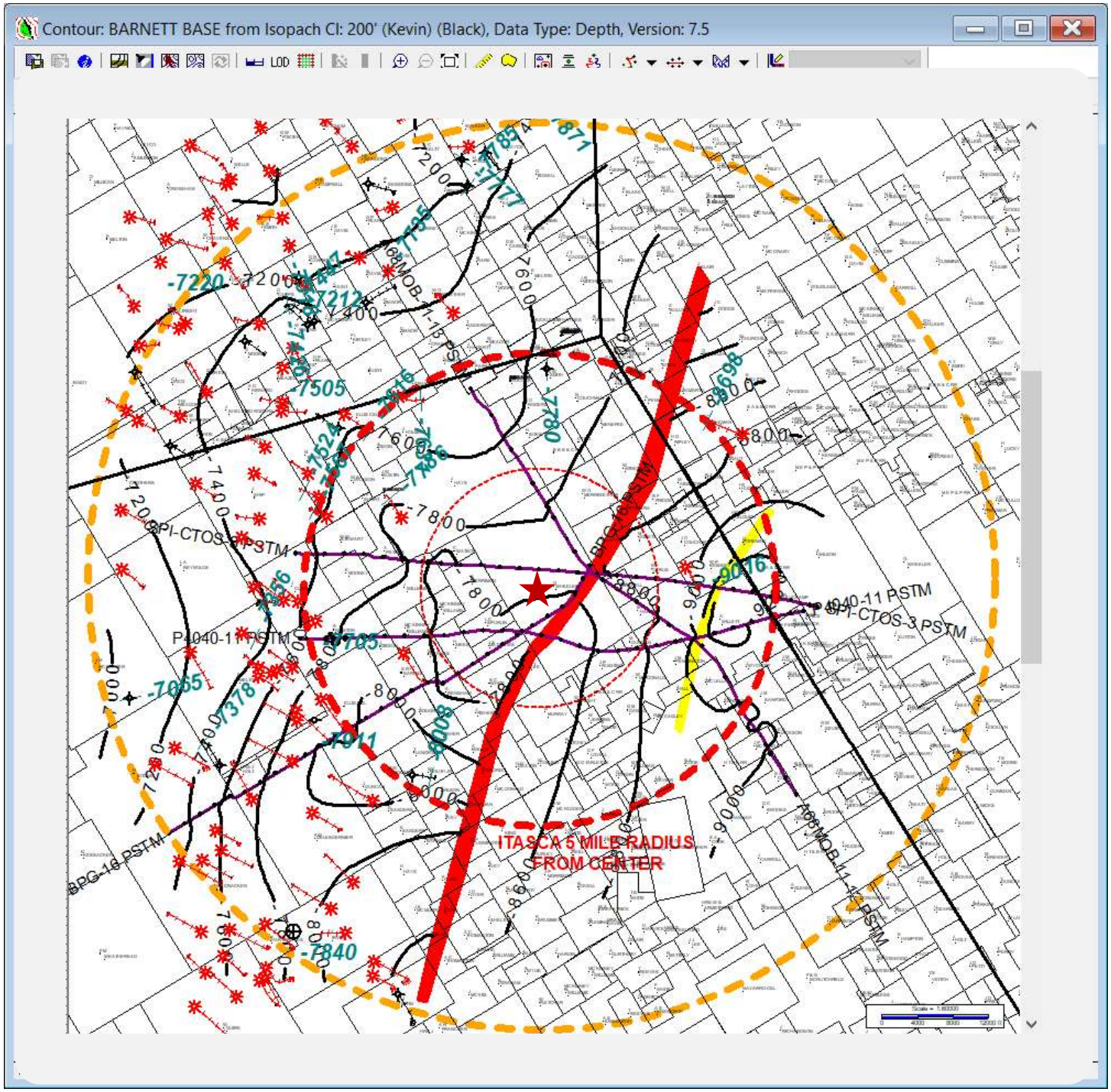
BASE BARNETT SHALE (from Isopach) STRUCTURE MAP DATUM: SEA-LEVEL CI: 200'

All wells with raster logs turned on



Seismic time converted to depth using wells and DDC.
Red and Yellow are down-to-the-east faults shown on the seismic data.

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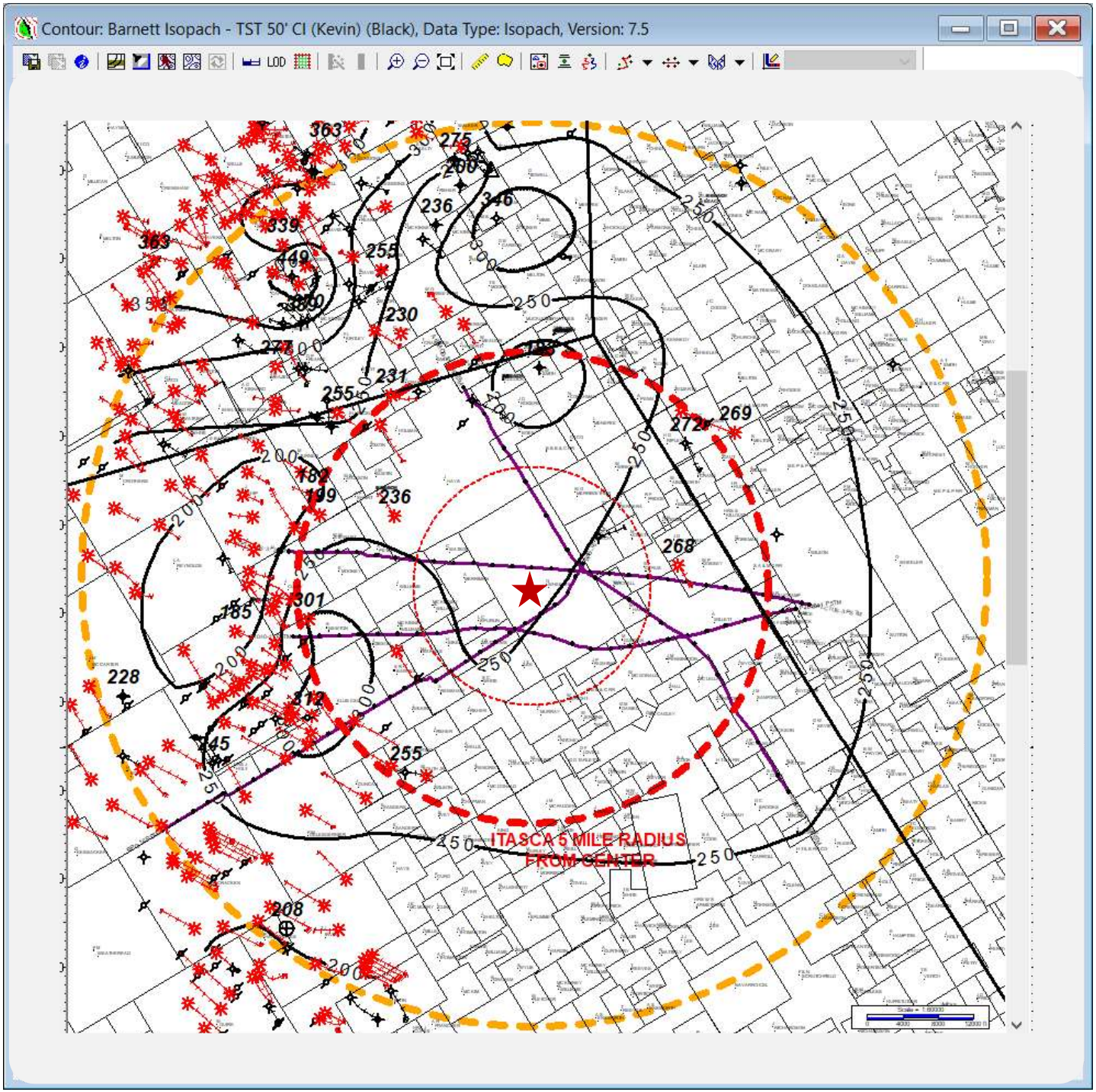
BARNETT SHALE ISOPACH MAP CI: 200’

All wells turned on



Values are from wells and seismic contours

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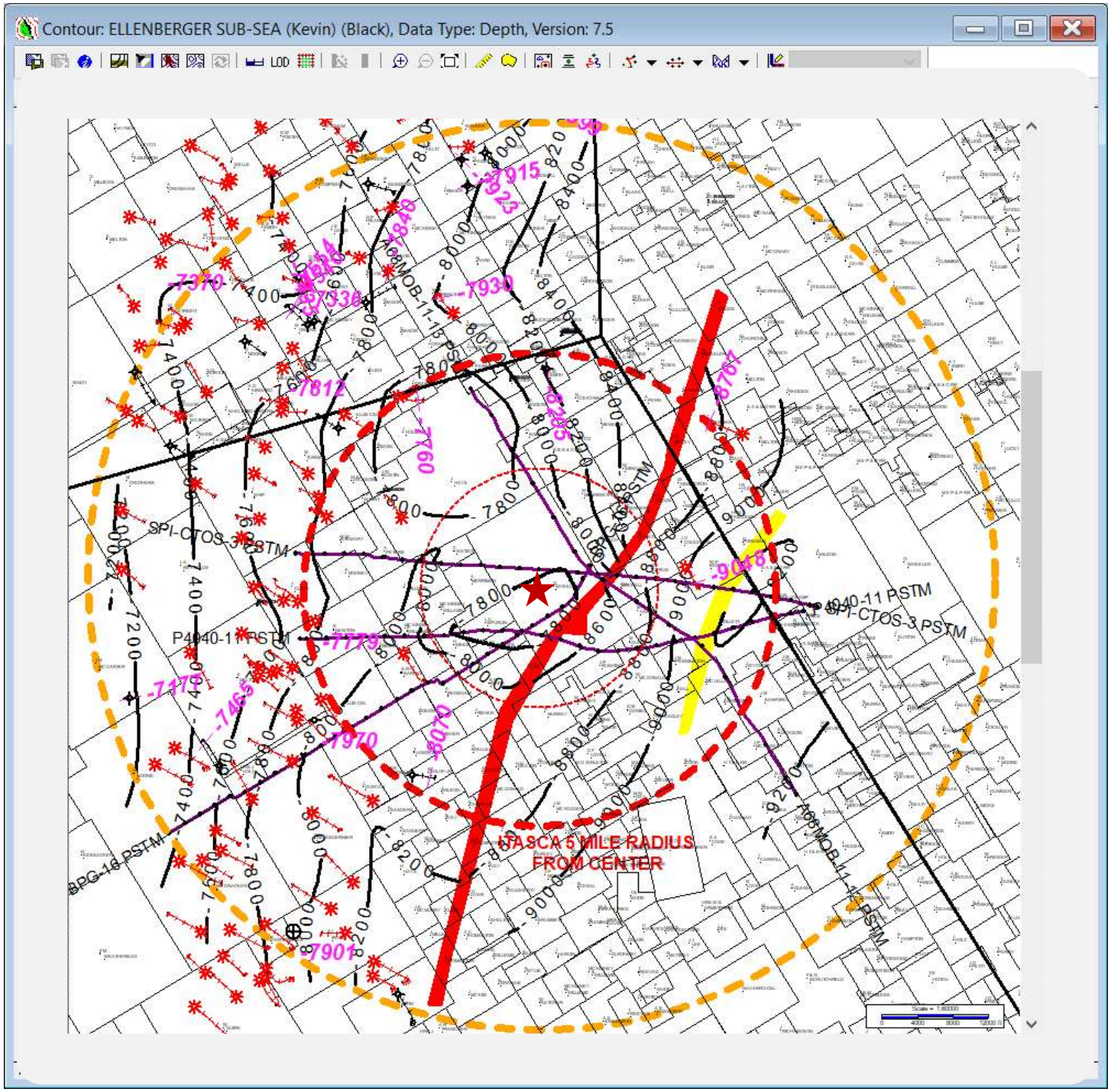
TOP ELLENBERGER STRUCTURE MAP DATUM: SEA-LEVEL CI: 200’

All wells with raster logs turned on



Seismic time converted to depth using wells and DDC. Red and Yellow are down-to-the-east faults shown on the seismic data.

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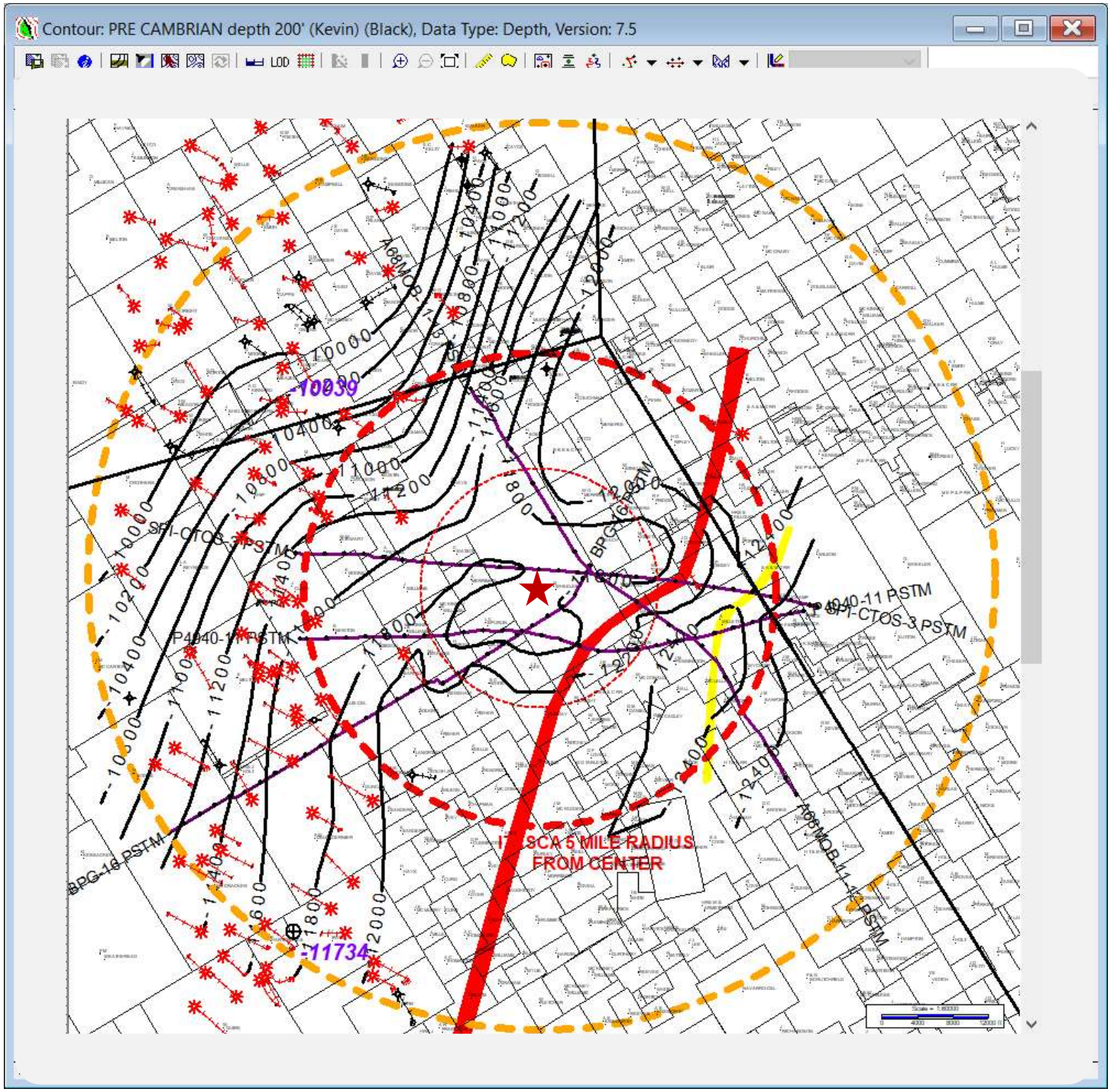
TOP PRE-CAMBRIAN GRANITE STRUCTURE MAP DATUM: SEA-LEVEL CI: 200’

All wells with raster logs turned on



Seismic time converted to depth using wells and DDC.
Red and Yellow are down-to-the-east faults shown on the seismic data.

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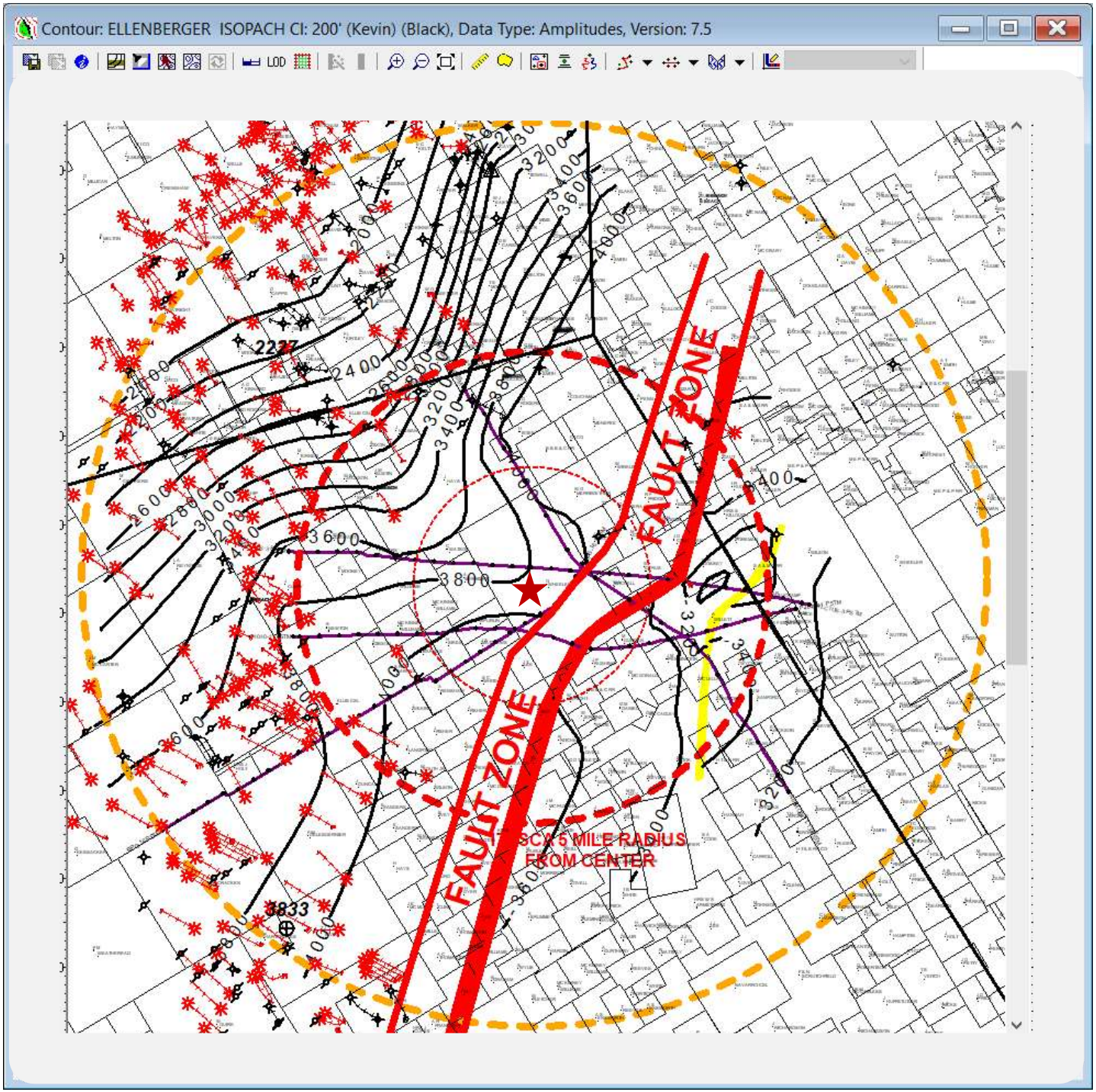
ELLENBERGER ISOPACH MAP (ELLENBERGER TOP – PRE-CAMBRIAN GRANITE) CI: 200’

All wells turned on



The red and yellow faults cause the isopach to be thin in the fault zone

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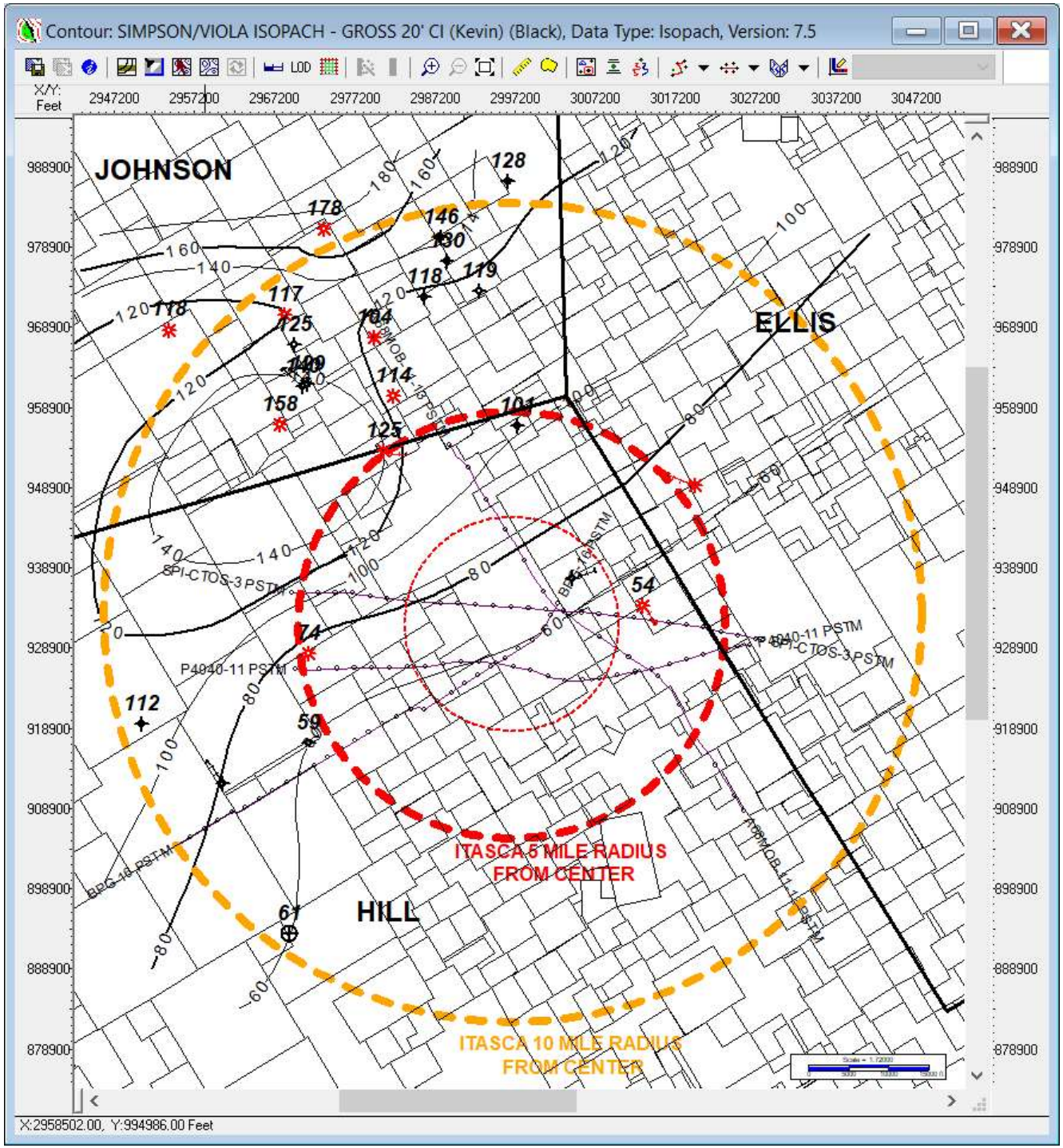
This map was made using the two wells penetrate the entire Ellenberger and by subtracting the top Ellenberger and top Pre-Cambrian Granite seismic layers.

SIMPSON/VIOLA ISOPACH CI:20’

All wells with raster logs that Simpson and Viola have log coverage are turned on.



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CONCLUSIONS:

Most wells in the area are horizontal and penetrate and log only the Barnett shale (main target) section. A few vertical wells in the study area penetrate the Ellenberger formation. The Simpson/Viola section is present in these wells and ranges from 54 to over 150 feet in thickness. One deep well penetrates the entire Ellenberger formation and shows many zones of porosity. 2d seismic data was licensed and reprocessed to aid in mapping of the area.

The sub-surface well logs and seismic data, when fully integrated, show a structural nose plunging to the southeast. On the southeast side of the study area, the structure is cut by a 200 foot +/- down-to-the-east fault (red) seen on the 2d seismic data. The fault would put up-thrown Ellenberger against Barnett, Simpson and Viola shale sections. Therefore, any porosity 300 feet below the top Ellenberger may have good potential for disposal.

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SECTION VI

INJECTION WELL ENGINEERING REPORT

ENGINEER'S SEAL

I, Raymond J. Steppe, III, P.E., the undersigned, state: I am employed by WSP USA, and I am authorized to prepare this document. This document was prepared under my supervision and direction. The information in this document was prepared in accordance with generally accepted engineering principles and practices.

This certification and seal apply to Injection Well Engineering Report (Section VI) and any specifications, details, calculations, or estimates contained therein. Any figures, drawings, or plans that require an original seal have been stamped, signed, and dated.

Name: Raymond J. Steppe, III, P.E.
Title: Principal Engineer
WSP USA Inc.
Texas Engineering Firm F-2263

STATE OF TEXAS
RAYMOND J. STEPPE, III
143783
LICENSED
PROFESSIONAL ENGINEER

Signature\Date Raymond J. Steppe, Dec 2023
Texas Registered Professional Engineer No. 143783

VI. INJECTION WELL ENGINEERING REPORT

VI.A PROPOSED CONSTRUCTION DETAILS

VI.A.1 ENGINEERING DRAWINGS OF THE PROPOSED WELL

The engineering drawings of the subsurface and surface schematics for the proposed well is provided in Figures VI-1 and VI-2, respectively. These figures include the proposed completion details and information on the type, size, description, and setting depths of tubing, casings and liners, cement types and location of cement behind casing, estimated Injection Zone, and Confining Zone.

VI.A.2 TOTAL DEPTH

The total depth of this well is proposed to approximately 12,400 ft BGL with the Long String Protection Casing set at 12,305 ft BGL.

VI.A.3 CASING AND TUBING

In accordance with the Class I Injection Well construction standards provided in 30 TAC §331.62(a), the proposed well has been designed to 1) prevent the movement of fluids along the wellbore into or between USDWs, 2) to prevent the movement of fluids along the wellbore out of the injection zone, 3) to permit the use of appropriate testing devices and workover tools, and 4) to permit continuous monitoring of injection tubing, long string casing and annulus. The length and quality of the surface casing is selected and designed to protect the lowermost USDW.

Table VI-1 presents the casing construction details. The casing to be used in the construction of the well will be designed for the life expectancy of the well, including the post-closure care period and will be emplaced in accordance with 30 TAC §331.62(a)(1)(A).

Table VI-2 presents the tubular detail including casing design safety factors. The proposed tubular program is rated to have sufficient structural strength to withstand, for the design life of the well, the maximum burst and collapse pressures and tensile stresses, which may be experienced at any point along the length of the casings at any time during the construction, operation, and closure of the well.

In addition, the casing details above, the surface casing setting depth was designed to be at 2,200 ft which is approximately 170 ft below the estimated base of USDW depth such that the USDW will be protected. The 7" production casing will extend past the confining zone and into the injection zone for the well.

(a) TUBULAR DESCRIPTION

The type, size, weight, grade, joint specification, length, setting depth and life expectancy of the tubulars are provided in Table VI-1.

(b) TUBULAR PERFORMANCE RATINGS

The tubular performance ratings for collapse resistance, internal yield pressure, and joint strength and the source of these ratings are provided in Table VI -2.

(c) MAXIMUM EXPECTED TUBULAR PRESSURES AND FORCES

The proposed tubular program is rated to have sufficient structural strength to withstand, for the design life of the well, the maximum burst and collapse pressures and tensile stresses, which may be experienced at any point along the length of the casings at any time during the construction, operation, and closure of the well and will be emplaced in accordance with 30 TAC §331.62(1)(A). The maximum expected tubular pressures and forces are presented in Table VI-2.

(d) TUBULAR DESIGN FACTOR CALCULATIONS

The detailed factor of safety calculations for burst pressure, collapse pressure, and joint strength for the tubulars are provided in Table VI-2. The minimum design factors used in the table are summarized below.

Minimum Design Factors:

Collapse Strength.....1.125
Joint Strength.....1.8
Plain-end Yield Strength.....1.50
Internal Yield Pressure.....1.1

(e) PACKER DESCRIPTION

The 7-inch x 4.5-inch retrievable packer with latching seal assembly will be set at 8,947 ft BGL, below the base of the proposed confining zone with a life expectancy commensurate with the tubulars.

(f) MATERIALS OF CONSTRUCTION SELECTION AND DESIGN PROCESS

The tubulars for each proposed well were selected and designed with the following considered: 1) base of USDW depth, 2) top of injection zone and top of interval depths, 3) estimated volume of injected fluids, 4) chemical composition, corrosive effects, temperature and density of injected fluids, annulus fluid, and formation fluids, 5) injection rates, 6) maximum pressures, 7) downhole equipment needs, 8) presence of lost circulation zones and other subsurface conditions, and 9) life expectancy of the well.

(g) TUBULAR INSPECTION, HANDLING, AND INSTALLATION

Below is a general procedure that will be used for inspecting, handling and installing the tubulars in the proposed well.

1. Obtain Mill Test Reports (MTRs) for each tubular string.
2. Have the following inspections performed in the pipe yard: Electro-Magnetic Inspection (EMI), Special End Area (SEA) and Full Length Drift (FLD).

3. Properly ship pipe to the wellsite when requested with thread protectors installed and with pipe properly stacked.
4. Pipe offloaded at wellsite with proper handling equipment and set on pipe racks near the well.
5. Thread protectors removed to clean threads and to apply proper thread compound, if necessary.
6. Pipe tallied for running in well.
7. Pipe picked up with thread protectors on using proper handling equipment.
8. Pipe made up with proper equipment to optimum torque using calibrated equipment.

VI.A.4 COMPLETION INTERVAL

The well is proposed to be cased hole completion with perforations within the Injection Interval from approximately 8,520 to 12,320 ft BGL. The specific target intervals to be perforated will be determined using the open hole logs in the 9 ½ inch hole section. The initial completion interval will incorporate the deepest target intervals and will be greater than 100 ft thick (Figure V-16 and Table V-2).

VI.A.5 CASING CENTRALIZERS

On the surface casing, centralizers will be installed near the float shoe, on the collars of the second and third joints, and on every third collar thereafter or where applicable. Wall scratchers will not be used.

On the protection casing, centralizers will be installed between the float shoe and float collar, on the collars of the first and second joints, and on every third collar thereafter or where applicable. Wall scratchers will not be used.

VI.A.6 CORROSION-INHIBITOR FLUID

Approximately 160 bbl of 9.1 lb/gal brine water containing a corrosion inhibitor with an oxygen scavenger and a bactericide will be placed between the injection tubing and protection casing. The fluid in the annulus will have a minimum concentration of corrosion inhibiting fluid of 2%. A differential of 100-psi greater than tubing pressure will be maintained as described in Section VI.A.12.

VI.A.7 DRILLING AND COMPLETION PROCEDURE

A drilling and completion procedure for the proposed well is presented as Appendix VI-1.

In the event that an injection well does not encounter porous formation, RIES will plug the wellbore, or plug back into another zone below the Confining Zone. Plugging and abandonment or recompletion will be carried out in accordance with RRC regulations.

(a) DRILLING PROBLEMS AND MANAGEMENT

The following discussion addresses plans to manage such problems as lost circulation zones, over-pressured zones, and stuck pipe. Lost circulation is the most common problem in drilling. The normal range of lost circulation problems begin in shallow unconsolidated sands and extends to the well consolidated formations that are fractured by the hydrostatic pressure imposed by the drilling fluid. In the shallow unconsolidated surface formations, the drilling fluid may flow freely into the formation because of its high permeability. Drilling may continue without circulation or the mud may be thickened to slow the rate of loss.

A general solution to lost circulation below the surface casing in normally pressured formations is to drill without fluid returns to the surface. This practice requires large volumes of water and close supervision. In principle, the generated cuttings are removed from bottom and deposited in the lost circulation zone. Specific problems in this part of the hole that may require attention include seepage losses, a complete loss of circulation where there is a requirement for obtaining cuttings back to the surface for formation evaluation purposes, and areas where there is a serious limitation on the available water supply. To prevent these problems, a fine or coarse lost-circulation material to reduce the rate of loss may be utilized. In general, the lost circulation material is used in the entire mud system for this type loss. Other options to control lost circulation include setting of cement plugs or utilizing an aerated fluid column or a viscous foam. The appropriate method which will be applied will be determined by the drilling equipment available, actual downhole conditions, and wellsite experience (Moore, 1974).

Over-pressured zones can be controlled by maintaining the proper mud weight column on the formation. A blowout occurs when the encountered formation pressure exceeds the mud column pressure, which allows the formation fluids to blow out of the hole. Proper mud density is the principal factor in avoiding this problem; however, borehole pressure reductions below mud column pressures are in many instances caused by too rapid withdrawal of the drill string. This is known as pipe pulling suction (swabbing) and has become recognized as a large factor promoting blowouts. This is particularly true in areas where a very delicate overbalance of formation pressure is necessary. The magnitude of the pulling suction depends on speed of pipe withdrawal, hole-pipe clearance, and mud viscosity and gel strength. This is a further argument for keeping mud viscosity at a minimum (Gatlin, 1960).

Stuck pipe is due to keyseating, an accumulation of cuttings around the pipe or balling up of the bit, and pipe being stuck in the filter cake. Keyseating is still recognized as a primary reason for sticking pipe. One recommendation for preventing this problem has been to keep the hole straight. This is recognized as a possible solution, but emphasis is placed on controlling rate of deviation and sudden changes in hole direction. Methods that can be used to free pipe from a keyseat include: (1) a jarring action, (2) spotting of oil to reduce friction, and (3) pipe rotation.

Hole cavings and cuttings that accumulate in cavities offer potential hazards to sticking pipe. Suggested methods for freeing pipe include: (1) if circulation is not possible, shut off the pump and release pressure; work pipe slowly, (2) if circulation is possible but limited, circulate clear water to help remove cuttings from around pipe and (3) if Step 2 is unsuccessful, spot oil around the pipe to reduce friction (Moore, 1974).

An evaluation of the Big Hill Field area did not indicate that any severe lost-circulation zones were encountered above the caprock Injection Interval. If circulation is lost above the Injection Interval, lost-circulation pills will

be pumped to regain circulation. Lost circulation will be controlled with cottonseed hull blends, paper, cement plugs, or other recommended lost-circulation materials as site-specific hole conditions warrant.

Lost circulation, however, is anticipated in the Injection Interval; the caprock is known for lost-circulation potential in this area. If lost circulation does occur while drilling the Injection Interval, the Injection Interval will be dry drilled using fresh water.

Pipe being stuck in the filter cake is known as differential pressure sticking. Again, to control differential sticking, the mud properties must be closely monitored so that a thick wall cake is not produced.

(b) DRILLING PROCEDURE

Discussion of the drilling procedure is detailed in Appendix VI-1.

(c) COMPLETION PROCEDURE

Discussion of the Completion Procedure is included in Appendix VI-1.

(d) DRILLING FLUID PROGRAM

Discussion of the drilling fluid program is included in Appendix VI-1.

VI.A.8 CEMENTING PROCEDURES

Selected service companies' cementing recommendations are presented in Appendix VI-2. The service companies' recommendations are based on experience and prior performance of past slurries applicable within the area around Hill County, Texas.

The presence of lost circulation zones, over-pressured zones, and other subsurface conditions have been discussed in Section VI.A.7.a and Appendix VI-1, Drilling and Completion Procedure.

(a) CEMENTING TECHNIQUE AND EQUIPMENT

The surface casing will be cemented utilizing the conventional method. A float shoe will be run on bottom with a float collar one joint off bottom. The cement will be pumped through the casing and displaced to the float collar while circulating cement back to the surface. No stage tools are to be used on the surface casing.

The intermediate casing will be cemented using the conventional method. A packoff float shoe will be run on bottom. The cement will be pumped through the casing and displaced to the float shoe while circulating cement back to the surface. A stage tool will be used, if needed.

The production casing will be cemented using the conventional method. A packoff float shoe will be run on bottom. The cement will be pumped through the casing and displaced to the float shoe while circulating cement back to the surface. A stage tool will be used, if needed. The cementing details can be found in Table VI-3.

Cement volumes for each casing string will be based on the annular volumes calculated from the open hole calipers run with the open hole logs before setting each casing string. For any borehole sections where washouts exceed the limit of the caliper measurement, 50% excess cement will be added for these hole sections. The type

of cement used will also be compatible with the injection fluids that can contact the cement across the perforated intervals.

All cement jobs will be pumped at sufficient injection rates and surface pressures such that the bottomhole fracture pressure of the formations is not reached and to reduce possible channeling in the annulus. To reduce contamination between the drilling fluids and cement material, the drilling fluids will be circulated to reach the same viscosity as the cement material. In addition, a spacer fluid (typically freshwater with additives) will be pumped before the cement material to reduce the chance of contamination between the drilling fluid and cement.

(b) CEMENTING CONTINGENCY PLAN

If circulation is lost while performing the cementing of the 10 ¾-inch or 7-inch cementing job, the operator will drop the cement plug and displace the cement to the float shoe. A temperature survey will be conducted in 8 hours after bumping the plug. If necessary, the top outside of the 10 ¾-inch casing or 7-inch will be cemented through a tremie pipe using 100 sacks of Class A cement. After completion of the cement job, the operator will drill out the float equipment and conduct bond logging to determine the top of cement. If necessary, the operator will perforate and squeeze to complete the cementing of the 10¾ inch casing.

VI.A.9 LOGGING AND CORING PROGRAMS

Table VI-4 contains the proposed logging program for the new well. All well logs, including all open hole logs and cement bond logs, will be interpreted by a qualified person and interpretations from the service company will also be provided.

Prior to injection into the well, a static bottom-hole pressure survey will be conducted when the well is completed. This will include pressure gradient stops. A pressure buildup/falloff test will then be conducted to verify and establish reservoir parameters.

Three conventional formation cores will be collected while drilling this well. One core will be taken in the lower Confining Zone and two cores are planned within the Injection Zone. Sidewall cores may be obtained from the Confining Zone and/or Injection Zone if conventional formation cores are not retrieved.

During completion of the initial well, a formation fluid sample will be recovered for chemical analysis. The sample will be recovered by utilizing a coiled tubing unit and nitrogen to backflow the well, swabbing, or by an electric wireline sampling device.

Table VI-5 contains the proposed coring program for the well.

(a) SURFACE CASING

Table VI-4 contains a list of Open Hole and Cased Hole logs that will be conducted from the proposed total depth of 2,200 feet to the base of the conductor casing set at 200 feet.

(b) INTERMEDIATE AND LONG-STRING CASING

Table VI-4 contains a list of Open Hole and Cased Hole logs that will be conducted for the intermediate casing/hole sections from the proposed total depth of 7,700 feet to the base of the surface casing set at 2,200 feet.

Also included in Table VI-4 is a list of Open Hole and Cased Hole logs that will be conducted for long-string casing/hole sections from the proposed total depth of 12,400 feet to the base of intermediate casing set at 7,700 feet.

(c) INJECTION AND CONFINING ZONES

i. Cores

One 4-inch diameter by 30-foot conventional core will be taken in the confining zone from approximately 8,350 feet to 8,380 feet BGL, and two 4-inch diameter by 30-foot conventional core will be taken in the Injection Zone from approximately 9,730 feet to 9,760 feet BGL and 11,230 feet to 11,260 feet BGL. Depending on the recovery of the conventional cores, sidewall cores will be taken in the Injection Zone and in the Confining Zone. The cores collected will be sufficient to characterize permeable and impermeable strata. Analysis of the core samples will include a determination of permeability, porosity, bulk density, Poisson's ratio, formation compressibility and any other necessary tests.

ii. Formation Fluid Sampling

During completion of the initial well, a formation fluid sample will be recovered for chemical, physical, and radiological analysis at a laboratory that is National Environmental Laboratory Accreditation Conference (NELAC) accredited by the Texas Laboratory Accreditation Program (TLAP) (30 TAC §331.121(a)(2)(H)). The sample will be recovered by utilizing a coiled tubing unit and nitrogen to backflow the well, swabbing, or by an electric wireline sampling device.

iii. Compatibility Testing of the Formation Fluids from the Injection and Confining Zones

From the formation fluid recovered and from the core samples obtained from the Confining Zone and Injection Interval, compatibility tests will be performed with the waste stream to demonstrate that the waste will not alter the permeability, thickness, or other relevant characteristics of the Confining Zone or the Injection Zone. Compatibility tests will also be performed to demonstrate that the waste mixed with the formation materials does not generate gases.

Per 30 TAC §§331.45(1)(G), 64(j) and 66(c), compatibility testing of the formation fluid, and minerals of both the Injection Zone and the Confining Zone, with the injected wastes will be conducted by a laboratory that is NELAC accredited by TLAP.

(d) WELL MECHANICAL INTEGRITY

The proposed well will be tested for mechanical integrity upon completion and annually thereafter, and the wellhead and annulus pressures will be continuously monitored. The mechanical integrity test (MIT) for new drilled wells and for annual demonstration will be performed in accordance with TCEQ's Basic Guidelines for Mechanical Integrity Tests and Related Cased Hole Wireline Logging dated May 4, 2021, or any subsequent revision.

i. Pressure Test

The integrity of the long-string casing, injection tubing and annular seal will be tested upon completion of the well and annually by means of an approved pressure test with a liquid or a gas and whenever there has been a well workover. Interpretation of the pressure test will be provided by the service company which performed the test or by other qualified persons.

ii. Radioactive Tracer Survey

The integrity of the bottom-hole cement will be tested upon completion of the well and annually by means of an approved radioactive tracer survey and after workovers that have the potential to damage the cement within the injection zone. Interpretation of the radioactive tracer survey will be provided by the service company which performed the test or by other qualified persons.

iii. Temperature or Noise Log

A temperature log, noise log or other approved log will be conducted upon completion of the well and at least once every five years to test for fluid movement along the borehole. Interpretation of the temperature or noise log will be provided by the service company which processed the logs or by other qualified persons as required by 30 TAC §331.62(a)(7)(A).

VI.A.10 WELL STIMULATION PROGRAM

Should it be determined after drilling the well that a stimulation of the Injection Interval is necessary, the well will be acidized using HCl or HCl-HF (Mud) Acid. Specific volumes and treatment specifications will be determined based on hole conditions. The stimulation program will be designed to achieve the needed injection capacity and injectivity parameters.

VI.A.11 INJECTIVITY TEST

In order to determine if stimulation of the Injection Interval is necessary, a short injectivity test will be conducted during the completion of the well. This injection period will serve as a baseline injectivity test for the well and would be conducted after stimulation, if required. Diagnostic surveys will be performed to establish an injection flow profile across the Injection Interval.

Prior to injection into the well, a static bottom-hole pressure survey will be conducted when the well is completed. This will include pressure gradient stops. The results obtained from the static bottom-hole pressure survey will be used to determine the bottom-hole pressure, temperature, and static fluid level. A representative formation fluid sample from the Injection Interval may be obtained at this time for chemical analysis, pending downhole conditions. Following the constant rate injection period, reservoir pressure will be monitored and recorded for at least 12 hours as a pressure falloff test. The falloff test will be analyzed to verify and establish Injection Interval parameters and will be run in accordance with the requirements of the TCEQ.

VI.A.12 ENGINEERING DRAWINGS AND DESIGN SPECIFICATIONS FOR THE WELLHEAD CONFIGURATION AND ANNULUS MONITORING SYSTEMS

Engineering drawings for the wellhead configuration and annulus monitoring system (WAMS) are provided as Figure VI-2 and Figure VI-3, respectively. The WAMS will be designed to maintain a 100-psi pressure greater than tubing pressure at any point along the tubing and packer.

VI.A.13 COMPATIBILITY OF MATERIALS OF CONSTRUCTION WITH INJECTION FLUID

RIES will operate a chemical neutralization system for incompatible wastes whereby any waste shipment with extremely high or low pH is neutralized as it is offloaded, prior to commingling with other wastes in above-ground storage tanks at the NTI Facility separately permitted waste receiving and processing facility. Since individual waste shipments will commonly range in pH between 8 and 11, and incompatible wastes will be neutralized, the corrosive nature of the NTI injection fluid is minimal. All well and piping materials were selected based on compatibility with the NTI injection fluid characteristics.

RIES will also conduct pH testing on each batch of injection fluid prior to commencing injection to assure compatibility with well components.

Once the wastewater constituency is finalized, compatibility testing of the construction materials will be done with this fluid and the cores obtained during drilling to make sure there is compatibility with the formation fluids as well.

VI.A.14 PLANS FOR NOTIFICATION

RIES plans to notify the TCEQ based on the regulatory requirements of the Texas Administrative Code for Class I nonhazardous waste disposal wells. A discussion of these notification requirements are provided below.

The executive director of TCEQ shall be given the opportunity under TAC §331.62(a)(10) to witness all cementing of casing strings, logging and testing. RIES shall submit a schedule of such activities to the executive director at least 30 days prior to commencing drilling of the well. The executive director shall be given at least a 24-hour notice before each activity in order that a representative of the executive director may be present.

RIES will meet the following four reporting requirements to TCEQ in accordance with TAC §331.65(b)(1) – (4):

(a) COMPLETION REPORT

Within 90 days after the completion or conversion of the well, RIES shall submit a Completion Report to the executive director per TAC §331.65(b)(1). The report must include a surveyor's plat showing the exact location and giving the latitude and longitude of the well. The report must also include a certification that a notation on the deed to the facility property or on some other instrument which is normally examined during title search has been made stating the surveyed location of the well, the well permit number, and its permitted waste streams. RIES shall also include in the report the following, prepared and sealed by a licensed professional engineer or licensed professional geoscientist with current registration under the Texas Engineering Practice Act or Texas Geoscience Practice Act:

- actual as-built drilling and completion data on the well;
- all logging and testing data on the well;
- a demonstration of mechanical integrity;
- anticipated maximum pressure and flow rate at which the NTI Facility will operate;
- results of the Injection Zone and Confining Zone testing program as required in TAC §331.62;
- adjusted formation pressure increases calculations, fluid front calculations and updated cross-sections of the confining and Injection Zones, based on the data obtained during construction and testing;
- the actual injection procedure;
- the compatibility of injected wastes with fluids in the Injection Zone and minerals in both the Injection Zone and the Confining Zone and materials used to construct the well;
- the calculated AOR and cone of influence (COI) based on data obtained during logging and testing of the well and the formation, and where necessary, revisions to the information submitted under TAC §331.121 of this title (relating to Class I Wells);
- the status of corrective action required for defective wells in the AOR;
- a Well Data Report on forms provided by the executive director;
- compliance with the casing and cementing performance standard in TAC §331.62(5); and
- compliance with the cementing requirements in TAC §331.62(6).

(b) LOCAL AUTHORITIES

The RIES shall provide written notice to the executive director, in a manner specified by the executive director, that a copy of the permit has been properly filed with the health and pollution control authorities of Itasca, Texas in Hill County.

(c) START-UP DATE AND TIME

The RIES shall notify the executive director in writing of the anticipated well start-up date. Compliance with all pre-operation terms of the permit will occur prior to beginning injection operations. RIES will notify the executive director at least 24 hours prior to beginning drilling operations.

(d) APPROVAL OF CONSTRUCTION AND COMPLETION

RIES shall obtain written approval from the executive director, in accordance with TAC §331.45, prior to beginning operations.

The executive director may approve or disapprove the construction and completion for an injection well or project in accordance with TAC §331.45 which provides the determination for the executive director to grant approval.

VI.B EXISTING WELL DESIGN AND CONDITION

Section VI.B is not applicable to this application. This permit application is for a new Class I well (see Section VI.A).

VI.C WELL OPERATIONS, MONITORING AND MAINTENANCE

VI.C.1 MAXIMUM INSTANTANEOUS INJECTION RATE

RIES requests that the proposed injection well program be permitted for a maximum instantaneous rate of injection not to exceed 102 gallons per minute (gpm) at any time.

VI.C.2 AVERAGE MONTHLY INJECTION RATE AND MONTHLY ANNUAL INJECTED VOLUMES

RIES requests that the proposed injection well program be permitted to average, on a monthly basis, 102 gpm. The average volume of wastewater injected shall be approximately 4,470,660 gallons per month, or 53,647,920 gallons per year based on 102 gpm.

VI.C.3 AVERAGE AND MAXIMUM DAILY INJECTION RATE AND LIFETIME INJECTION VOLUME

Given the proposed average injection rate of 102 gpm (which is also the maximum requested), the maximum daily injection volume is 146,880 gallons per day. Over the 30 year operational period, the injection volume is 1,609,437,600 gallons.

The proposed injection well will operate on a 24-hour basis.

VI.C.4 MAXIMUM SURFACE INJECTION PRESSURE (MSIP)

Figure VI-4 and Table VI-6 shows maximum allowable surface injection pressures (surface injection pressure) versus specific gravity of the waste stream. The injected waste stream will be a blended aqueous solution produced from offsite sources and some onsite sources. Physical characteristics of the waste stream may vary based on the source component concentrations. The temperature of the injectate will be at ambient conditions.

The specific gravity of the waste stream is expected to range from 0.90 to 1.20 at 68°F (20°C), and the viscosity of the waste stream will vary based on its specific gravity and temperature. The injection well will be operated with a continuous positive surface injection pressure.

The maximum pressure gradient of 0.702 psi/ft is maintained at the site. RIES is requesting a waste stream dependent MSIP which will be based on the specific gravity of the waste stream that will be monitored at the facility. The MSIP values were calculated at the top of the proposed injection interval depth of 8,520 feet BGL

which includes a 100 psig safety factor to stay below the fracture pressure. A detailed calculation of the MSIP is described in Section VII.A.5. RIES is requesting the following MASIP values based on calculations in Table VI-6:

- 1900 psig for wastes with Specific Gravity less than or equal to 1.079;
- 1800 psig for wastes with Specific Gravity greater than 1.079 and less than or equal to 1.1063;
- 1700 psig for wastes with Specific Gravity greater than 1.1063 and less than or equal to 1.1334;
- 1600 psig for wastes with Specific Gravity greater than 1.1334 and less than or equal to 1.1605;
- 1454 psig for wastes with Specific Gravity greater than 1.1605 and less than or equal to 1.20;

VI.C.5 OPERATION AND INJECTION PROCEDURES

Per 30 TAC 331.63(g), RIES will ensure gauges and pressure sensing and recording devices are calibrated quarterly.

RIES will maintain pressure gauges at the wellheads in accordance with 30 TAC 331.64(c). RIES will ensure these gauges are maintained in operable condition at all times on the injection tubing and on the tubing/long-string casing annulus. Maintaining these gauges ensures the facility is able to detect anomalies in the permitted operating parameters that will help detect a loss of mechanical integrity that could potentially lead to unwanted injection into an unauthorized zone or leakage to a USDW.

Per 30 TAC 331.64(d), RIES will maintain instrumentation for the injection well that is contained in a fully enclosed weatherproof enclosure. The instruments measure and continually monitor and record the injection tubing pressure, flow rate, injection fluid temperature, tubing/long-string casing, annulus pressure, and the volume injected into the injection well. An automatic alarm system is used that is designed to sound when any parameter approved by the TCEQ has exceeded the approved range. The instrumentation will ensure that the facility is operating within the permitted parameters, including not exceeding the MSIP (Section VI.C.4) to ensure the formation is not fractured and maintaining an annulus pressure at least 100 psi greater than the injection pressure.

RIES will take appropriate action if any parameter approved by the TCEQ exceeds the approved range. The TCEQ will be notified within 24 hours of any loss of mechanical integrity or any violation of Injection Zone and/or USDW integrity.

RIES will maintain the injection wellhead and related equipment in good working order in accordance with 30 TAC 331.66(3).

Additionally, RIES will monitor the waste stream ensuring the waste characteristics parameters do not exceed permit limits. Section IX.A.6 discusses this further.

Prior to commencing any workovers, RIES will notify the TCEQ with details of the work planned. In addition, the TCEQ will be notified prior to resuming well operations should the well not be operated for more than two years.

VI.C.6 DETAILED MONITORING PLANS WITH ENGINEERING DIAGRAM

(a) WELLHEAD PRESSURE GAUGES

Pressure gauges are installed at the wellhead and properly maintained at all times to monitor the pressure of the injection tubing and the tubing-casing annulus. RIES will continuously monitor and record tubing pressures, injection flow rates, injection fluid temperatures, injection volumes, tubing-casing-annulus differential pressure, and volume. The instrumentation is protected from the environment and regularly checked. Calibration is performed quarterly. Additional monitoring and maintenance procedures are described in Section VI.C.7.

(b) RECORDING DEVICES AND ALARM, SHUTOFF, AND RESPONSE SYSTEMS

The injection tubing pressure, injectate specific gravity, injection flow rates and temperatures, totalized injection volume, and annulus pressure are continuously and digitally recorded. The well annulus monitoring system is monitored for pressure, with the data recorded continuously, and monitored for fluid level (annulus system volume). All instrumentation is enclosed in weatherproof housings. In the event of any anomalous performance for any parameter of the injection well, alarms will be activated. An operator, trained in how to respond to the alarms, will be on site and take immediate action. Record keeping and recording is performed to ensure compliance with U.S. Environmental Protection Agency (EPA) - and TCEQ - approved parameters.

In the event of an alarm or shutoff, RIES will investigate and identify as expeditiously as possible the cause of the alarm or shutoff. If the well appears to be lacking mechanical integrity, RIES will immediately cease injection of waste fluids unless authorized by the TCEQ Executive Director to continue or resume injection (30 TAC §331.64(d)). RIES will take all necessary steps to determine the presence or absence of a leak.

Should a loss of mechanical integrity be confirmed through monitoring activities, RIES will immediately cease injection of waste fluids and take all steps reasonably necessary to determine whether there may have been a release of waste into any unauthorized zone (30 TAC §331.64(d)).

RIES will notify the TCEQ Executive Director within 24 hours if a loss of mechanical integrity is reasonably suspected or confirmed (30 TAC §331.64(d)). RIES will notify the TCEQ Executive Director when injection can be expected to resume. Following restoration of mechanical integrity, the mechanical integrity of IW-1 will be demonstrated to the satisfaction of the TCEQ Executive Director prior to resuming injection of waste fluids (30 TAC §331.64(d)).

Should RIES obtain evidence that injected waste may have been released into an unauthorized zone, RIES will immediately cease injection of waste fluids and notify the TCEQ Executive Director within 24 hours of obtaining such evidence. RIES will take all necessary steps to identify and characterize the extent of any release and propose a remediation plan for the TCEQ Executive Director's review and approval. RIES will comply with and implement the remediation plan agreed to with the TCEQ Executive Director (30 TAC §331.64(d)).

Should it be determined that such a release is into a freshwater aquifer or USDW currently serving as a water supply, RIES will, within 24 hours, notify the local health authority, place a notice in a newspaper of general circulation, and send notification by mail to adjacent landowners (30 TAC §331.64(d)).

(c) WASTE MONITORING

Injectate grab samples are taken at least every two hours and measured for specific gravity. Once the specific gravity is measured, a chart is used to correct the specific gravity reading to a reference temperature of 68°F. The temperature-corrected reading is recorded on the "Two Hour Monitoring Log".

Prior to starting a new tank downhole for injection, the density of the tank material will be measured continuously. If the density is greater than the maximum allowed, the tank is blended with lighter compatible wastes such that the specific gravity is within the acceptable range.

Automated measurements of pH will be collected from the injectate every two hours. The result comes from a standard electronic pH meter that is calibrated daily. The waste management units are defined in Table VI-7 as well as described in Section XII.

All of the instruments discussed above are calibrated quarterly to ensure accuracy in their readings, unless otherwise specified. RIES employees will be trained in permit and petition-specific procedures regarding maximum and minimum allowable parameter settings, along with alarm set points and the immediate response to those critical alarms.

(d) ANNUAL MECHANICAL INTEGRITY TESTING

The mechanical integrity testing, including annulus pressure test (APT); radioactive tracer survey (RAT); temperature, noise or oxygen activation log every five years; and casing inspection log when tubing is pulled during workover and/or every five years as needed, will be performed as required by 30 TAC §331.64(e).

(e) QUARTERLY CORROSION MONITORING

As discussed in Section VI.B.3, RIES will conduct corrosion monitoring on a quarterly basis using test coupons constructed from carbon steel, the materials of construction used in the injection tubing, packer and long-string casing in IW-1 as required by 30 TAC §331.64(g). These coupons will be exposed continuously to waste at operating pressures, temperatures and flow rates. The corrosion coupon loop will be located near the IW-1 wellhead. The corrosion coupons are evaluated on a quarterly basis for loss of mass thickness, cracking, pitting, and other signs of corrosion to meet the minimum standards of material strength and performance. Appendix VI-3 provides a template for evaluating corrosion coupons.

(f) ANNUAL PRESSURE BUILDUP MONITORING

RIES will conduct annual pressure buildup monitoring of the Injection Interval as required by EPA and TCEQ including a maximum sustainable injection rate and a shut-down of the well for a time sufficient to conduct a valid observation (enough time to reach radial flow in the reservoir for analysis) of the pressure falloff curve. In addition, a permanent pressure-temperature gauge may be installed near the injection packer to provide continuous bottomhole pressure data.

VI.C.7 WELLHEAD MAINTENANCE

The wellheads and the associated facilities will be painted to prevent corrosion and maintained in good working order without leaks as required per 30 TAC §331.66(b)(3).

VI.C.8 IMPERMEABLE AREA AROUND WELLHEAD

The IW-1 wellhead is constructed on impermeable pads that are designed to prevent downward vertical migration of a spill or release of injection fluid.

VI.C.9 ALL-WEATHER ROAD

RIES will maintain all-weather roads to allow access to the injection wells and related facilities.

VI.C.10 SIGN AT WELLSITE

RIES will post a sign at each wellsite identifying the well in compliance with 30 TAC §331.66(b)(1).

VI.C.11 CONTINGENCY PLAN

The proposed injection well will be equipped with a high-level shutoff switch to prevent operation of the injection pump at pressures greater than the designated MASIP. The wells are also equipped with a low-pressure shutoff switch that will deactivate the injection pump in the event of a surface leak. In addition, the proposed well will be equipped with a high/low pressure shutdown switch with a pressure sensor on the tubing/casing annulus. This pressure switch is intended to stop the injection pump in the event of 1) a tubing leak, or 2) a casing, packer, or wellhead leak.

If an alarm or shutdown is triggered, the cause of the alarm or shutdown will be immediately investigated to identify the root cause of the situation.

- Immediately cease injection operations;
- Take all necessary steps to determine the presence or absence of a leak; and
- Provide verbal notification to TCEQ within 24 hours.

If the alarm or shutdown is not related to mechanical integrity and the cause of the alarm or shutdown is corrected, injection operations will be resumed. If the mechanical integrity of the well is in question, the well will remain out of service until mechanical integrity has been restored to the satisfaction of TCEQ and the agency approves resumption of injection operations.

If operation of the injection well is disrupted for an extended period, the facility will not receive any additional shipments of waste until the well has been returned to service. If necessary, the waste will be diverted to another commercial Class I hazardous waste injection well facility in the area.

Once the facility is complete, RIES will prepare and implement a Spill Prevention Control and Countermeasure Plan (SPCC plan) to provide for emergency conditions and/or worst-case scenarios such as catastrophic well failure and/or 100-year rainfall event.

VI.D WELL CLOSURE, POST-CLOSURE CARE AND COST ESTIMATES

VI.D.1 WELL CLOSURE PLAN

A Well Closure Plan is included in Appendix VI-4.

IW-1 will be plugged and abandoned in accordance with 31 TAC §331.46. NTI will notify the Executive Director 60 days prior to initiating the well closure plan.

New information from existing wells and information about newly constructed or discovered wells within the AOR will be considered to determine the adequacy of the closure plan and will be included in the closure report.

Prior to closure and after ceasing injection in the well to be closed, a pressure falloff test will be conducted in order to determine if the transient pressure data have conformed to predicted values within the Injection Interval. The brine injected for the falloff test will be nonhazardous and will also act as a buffer between the injectate and the well.

A mechanical integrity test shall be conducted to ensure the integrity of the long casing string and cement that will remain in the ground after closure. The mechanical integrity test will determine whether remedial cement squeeze operations will be necessary prior to plugging. After remedial cement squeeze operations, if required, the well will be plugged with a series of cement plugs.

The casing will be filled to the surface with a series of balanced cement plugs. After waiting for 24 hours for the cement to cure, the upper plug will be tested for seal and stability. If necessary, additional cement will be circulated to fill the well to the surface.

The casings will be cut off +/- 3 feet below ground level, and a ½-inch thick steel plate will be welded onto the top of the casing.

A closure report will be submitted within 30 days after completion of closure. The report will be certified as accurate by the owner or operator and by the person who performed the closure operation. The report will state that the well was closed in accordance with the closure plan previously submitted to and approved by the TCEQ. Where the actual closure differed from the submitted plan, a written statement will be included specifying the differences between the submitted plan and the actual closure.

A permanent marker will be placed at the well site. The marker will state the facility well number, TCEQ permit number, years of operation, injected volumes, date of abandonment, and company name.

All cleanup action required under 40 CFR §146.64 will continue and be completed during closure. No cleanup of any type is currently anticipated.

A survey plat will be sent to the local zoning authority and to the TCEQ. The plat shall indicate the location of the well relative to permanently surveyed benchmarks. A copy of the plat will be submitted to the local zoning authority, as designated by the Executive Director, and to the UIC Unit at the Austin office of the TCEQ.

The RRC will be notified of the closure of the subject wells. Included with the notification will be information regarding the chemical nature of the injected waste stream, delineation of the projected waste plume, identification of the depths of the injection and Confining Zones, the pressure in the Injection Zone before injection began and the anticipated pressure in the Injection Zone at the time of closure, injection well schematics, and plugging records. This will enable the RRC to impose appropriate conditions on subsequent drilling activities that may penetrate the well's confining or Injection Zones.

VI.D.2 COST ESTIMATE FOR PROPOSED CLOSURE PLAN

A bond has been obtained to cover the plugging and abandonment of IW-1(Appendix VI-5). The detailed closure cost is presented for IW-1 in Appendix VI-6.

VI.D.3 POST-CLOSURE CARE PLAN

RIES will retain for 3 years after closure all records reflecting the nature, composition, and volume of the injected fluids per §331.67 (c). Following the 3-year retention period, the records will be delivered to the Executive Director of the TCEQ. Thereafter, all records will be retained at a location designated by the TCEQ Executive Director for that purpose. Corrective action after closure of IW-1 is not anticipated.

VI.D.4 COST ESTIMATE FOR POST-CLOSURE CARE PLAN

The estimated cost for the post-closure care activities for IW-1 is $526,478. The post-closure plan (Appendix VI-4) and a cost estimate to implement the post-closure plan for the proposed new well is included in Appendix VI-6.

TABLES

Table VI-1

Construction Details

Casing Type	Casing Size	Casing Description	Casing Depth	Cement (sacks)	Top of Cement	Life Expectancy Years	Estimated Injection Zone (Ft)	Estimated Confining Zone (Ft)
Conductor	20	Beveled Shoe, Carbon Steel, Drive Pipe, 0.375" WT	120	114	Surface	30	8,520 – 12,320	8,260-8,520
Surface	16	75 lb/ft, J-55, BTC, 0.375" WT, Carbon Steel	2,200	700	Surface	30		
Intermediate	10 ¾	55.5 lb/ft, P-110, LT&C, 0.495" WT, Carbon Steel	7,700	1225	Surface	30		
Production	7	29 lb/ft, P-110, LT&C, 0.408" WT, Carbon Steel	12,305	2320	Surface	30		

TABLE VI-2

Section	Outside Diameter (in)	Depth Interval (Feet BGL)	Material	Performance Properties				Loads				Factor of Safety			
				Collapse Resistance (psi)	Internal Yield (psi)	Joint Strength (lbf)	Minimum Yield (psi)	Max. External (psi)	Max. Internal (psi)	Max. Tensile Load (lbs)	Max Triaxial Stress on Pipe Body (psi)	Safety Factor Collapse (≥1.125)	Safety Factor Burst (≥1.1)	Safety Factor Tension (≥1.8)	Pipe Body Yield (≥1.5)
Conductor	20	0 - 120	78.37 ppf; 0.375" wall, augured	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Surface Casing	16	0 - 2200	75 ppf; J-55, BT&C	1,020	2,630	1,200,000	55,000	855	1,934	500,000	35,948	1.19	1.36	2.40	1.53
	Reference							A	B	B	B	A	B	B	B
Intermediate Casing	10 3/4	0 - 7700	55.5 ppf; P-110; ST&C	4,610	8,860	1,202,000	110,000	1,707	2,188	469,531	29,491	2.70	4.05	2.56	3.73
	Reference							F	E	C	C	F	E	C	C
Production Casing	7	0 - 12,305	29 ppf; P-110; LT&C	8,530	11,220	797,000	110,000	3,036	3,431	402,525	47,619	2.81	3.27	1.98	2.31
	Reference							H	I	G	G	H	I	G	G
Injection Tubing	4 1/2	0 - 8,947	11.6 ppf; N-80; LT&C	6,350	7,780	223,000	80,000	3,802	6,199	100,000	37,383	1.67	1.26	2.23	2.14
	Reference							K	L	J	K	K	L	J	K

Reference	A	Annulus Filled With Cement: Internal Pressure: 8.33 ppg Hydrostatic. External Pressure: 15.8 ppg Fluid Density to Shoe
	B	Pressure Test: Internal Pressure: 1,000 psi Surface Test Pressure on top of 16.40 ppg fluid gradient. External Pressure: 8.33 ppg Fluid Density to Previous Shoe; Pore Pressure to Shoe
	C	Overpull: Internal Pressure: 9.00 ppg Fluid Hydrostatic. External Pressure: 9.00 ppg Fluid Hydrostatic
	D	Cement Filled Annulus (1st Stage)Internal Pressure: 8.33 ppg Hydrostatic. External Pressure: 8.33 ppg Hydrostatic to DV Tool. 16.40 ppg Fluid Density to Shoe
	E	Bump Plug (1st Stage):Internal Pressure: 8.33 ppg Displacing Fluid Hydrostatic. 2190 psi to bump plug. External Pressure: 9.0 ppg fluid density to DV tool. 16.40 ppg Fluid Density to shoe
	F	Cement Filled Annulus (2nd Stage)Internal Pressure: 8.33 ppg fluid hydrostatic to DV Tool. External Pressure: 16.40 ppg Fluid Density to Shoe
	G	Overpull: Internal Pressure: 10.00 ppg Fluid Hydrostatic. External Pressure: 10.00 ppg Fluid Hydrostatic
	H	Cement Filled Annulus (2nd Stage): Internal Pressure: 8.33 ppg Fluid Hydrostatic to DV Tool. External Pressure: 16.4 ppg Fluid Density to DV Shoe
	I	Bump Plug (2nd Stage): Internal Pressure: 8.33 ppg Displacing Fluid Hydrostatic. 3,435 psi Pressure Used to Bump Plug. External Pressure: 16.40 ppg Fluid Density to DV Tool
	J	Running in Hole: Internal Pressure: 10.00 ppg Fluid Hydrostatic. External Pressure: 10.00 ppg Fluid Hydrostatic, Running velocity of 2.0 ft/sec
	K	Pressure Test: Internal Pressure: 8.33 ppg Hydrostatic. External Pressure: 2935 psi at hanger, 10.00 ppg fluid density to packer.
	L	Internal Pressure: 1550 psi surface pressure on top of 10.00 ppg fluid hydrostatic. External Pressure: 0 psi

Table VI-3

Cementing Program

Casing	Size (inches)	Hole Size (inches)	Depth (feet)	Remarks
Conductor	20	24" (augured)	120	Augured to 120 ft inside 24" hole and cemented with ReadyMix (or equivalent) with ~114 sacks
Surface	16	18 1/8	2,200	Lead Cement: 450 sacks* of Extendacem mixed 12.0 ppg. Tail Cement 250 sacks* of Halcem cement mixed 15.0 ppg. * Based on 50% excess cement.
Intermediate	10¾	13 ½	7,000	Stage collar set at 4000 feet. Stage 1: (7,700 ft to 4,000 ft) Lead Cement: 590sacks** of Neocem mixed 12.5 ppg. Tail Cement: 635sacks** of Neocem cement mixed at 14.5 ppg. Stage 2: (4,000 ft to surface) Lead Cement: 700 sacks** of Extendacem 12.0 ppg. Tail Cement: 410 sacks** of Halcem 15.0 ppg ** Based on 20% excess cement.
Production	7	9 1/2	12,305	Stage collar set at 7,000 ft Stage 1: (12,305 ft to 7,000 ft) Lead Cement: 245 sacks** of Neocem 12.5 ppg. Tail Cement: 840 sacks** of Neocem 14.5 ppg. Stage 2: (7,000 ft to surface) Lead Cement: 775 sacks** of Neocem 12.5 ppg. Tail Cement: 460 sacks** of Neocem 14.5 ppg. ** Based on 20% excess cement.

TABLE VI-4
LOGGING PROGRAM

HOLE/CASING LOCATION	OPEN HOLE LOGS	CASED-HOLE LOGS
18 ⅛ Inch Surface Borehole (16 Inch Casing) 2,200 Feet	— Spontaneous Potential — Dual Induction-Resistivity — Compensated Neutron/Formation Density — Caliper — Gamma Ray	— Temperature/Cement Bond/Variable Density
13 ½ Inch Long-string Borehole (10 ¾ Inch Casing) 7,700 Feet	— Spontaneous Potential — Dual Induction-Resistivity — Caliper — Compensated Neutron/Formation Density — Gamma Ray — Fracture Identification Survey — Inclination Survey	— Temperature/Cement Bond/Variable Density — Casing Inspection Log
9 ½ Inch Long-string Borehole (7 Inch Casing) 12,305 Feet	— Spontaneous Potential — Dual Induction-Resistivity — Caliper — Compensated Neutron/Formation Density — Gamma Ray — Fracture Identification Survey — Inclination Survey	— Temperature/Cement Bond/Variable Density — Casing Inspection Log — Radioactive Tracer

TABLE VI-5

CORING PROGRAM

Type of Core	Depth	Lithology	Petition Interval
Conventional 4" x 30'	8350 - 8380 feet	Shale	Confining Zone
Conventional 4" x 30'	9730 – 9760 feet	Carbonate	Injection Zone
Conventional 4" x 30'	11230 – 11260 feet	Carbonate	Injection Zone

TABLE VI-6
MSIP vs. Waste Stream Specific Gravity

Specific Gravity	Hydrostatic Head (psi)	MSIP[1] (psi)
0.9000	3320	2561
0.9010	3324	2557
0.9020	3328	2553
0.9030	3331	2550
0.9040	3335	2546
0.9050	3339	2542
0.9060	3342	2539
0.9070	3346	2535
0.9080	3350	2531
0.9090	3353	2528
0.9100	3357	2524
0.9110	3361	2520
0.9120	3365	2517
0.9130	3368	2513
0.9140	3372	2509
0.9150	3376	2505
0.9160	3379	2502
0.9170	3383	2498
0.9180	3387	2494
0.9190	3390	2491
0.9200	3394	2487
0.9210	3398	2483
0.9220	3401	2480
0.9230	3405	2476
0.9240	3409	2472
0.9250	3412	2469
0.9260	3416	2465
0.9270	3420	2461
0.9280	3424	2457
0.9290	3427	2454
0.9300	3431	2450
0.9310	3435	2446
0.9320	3438	2443
0.9330	3442	2439
0.9340	3446	2435
0.9350	3449	2432
0.9360	3453	2428
0.9370	3457	2424
0.9380	3460	2421
0.9390	3464	2417
0.9400	3468	2413
0.9410	3471	2410
0.9420	3475	2406
0.9430	3479	2402

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

0.9440	3483	2398
0.9450	3486	2395
0.9460	3490	2391
0.9470	3494	2387
0.9480	3497	2384
0.9490	3501	2380
0.9500	3505	2376
0.9510	3508	2373
0.9520	3512	2369
0.9530	3516	2365
0.9540	3519	2362
0.9550	3523	2358
0.9560	3527	2354
0.9570	3531	2351
0.9580	3534	2347
0.9590	3538	2343
0.9600	3542	2339
0.9610	3545	2336
0.9620	3549	2332
0.9630	3553	2328
0.9640	3556	2325
0.9650	3560	2321
0.9660	3564	2317
0.9670	3567	2314
0.9680	3571	2310
0.9690	3575	2306
0.9700	3578	2303
0.9710	3582	2299
0.9720	3586	2295
0.9730	3590	2291
0.9740	3593	2288
0.9750	3597	2284
0.9760	3601	2280
0.9770	3604	2277
0.9780	3608	2273
0.9790	3612	2269
0.9800	3615	2266
0.9810	3619	2262
0.9820	3623	2258
0.9830	3626	2255
0.9840	3630	2251
0.9850	3634	2247
0.9860	3638	2244
0.9870	3641	2240
0.9880	3645	2236
0.9890	3649	2232
0.9900	3652	2229

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

0.9910	3656	2225
0.9920	3660	2221
0.9930	3663	2218
0.9940	3667	2214
0.9950	3671	2210
0.9960	3674	2207
0.9970	3678	2203
0.9980	3682	2199
0.9990	3685	2196
1.0000	3689	2192
1.0010	3693	2188
1.0020	3697	2185
1.0030	3700	2181
1.0040	3704	2177
1.0050	3708	2173
1.0060	3711	2170
1.0070	3715	2166
1.0080	3719	2162
1.0090	3722	2159
1.0100	3726	2155
1.0110	3730	2151
1.0120	3733	2148
1.0130	3737	2144
1.0140	3741	2140
1.0150	3744	2137
1.0160	3748	2133
1.0170	3752	2129
1.0180	3756	2125
1.0190	3759	2122
1.0200	3763	2118
1.0210	3767	2114
1.0220	3770	2111
1.0230	3774	2107
1.0240	3778	2103
1.0250	3781	2100
1.0260	3785	2096
1.0270	3789	2092
1.0280	3792	2089
1.0290	3796	2085
1.0300	3800	2081
1.0310	3804	2078
1.0320	3807	2074
1.0330	3811	2070
1.0340	3815	2066
1.0350	3818	2063
1.0360	3822	2059
1.0370	3826	2055

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

1.0380	3829	2052
1.0390	3833	2048
1.0400	3837	2044
1.0410	3840	2041
1.0420	3844	2037
1.0430	3848	2033
1.0440	3851	2030
1.0450	3855	2026
1.0460	3859	2022
1.0470	3863	2018
1.0480	3866	2015
1.0490	3870	2011
1.0500	3874	2007
1.0510	3877	2004
1.0520	3881	2000
1.0530	3885	1996
1.0540	3888	1993
1.0550	3892	1989
1.0560	3896	1985
1.0570	3899	1982
1.0580	3903	1978
1.0590	3907	1974
1.0600	3911	1971
1.0610	3914	1967
1.0620	3918	1963
1.0630	3922	1959
1.0640	3925	1956
1.0650	3929	1952
1.0660	3933	1948
1.0670	3936	1945
1.0680	3940	1941
1.0690	3944	1937
1.0700	3947	1934
1.0710	3951	1930
1.0720	3955	1926
1.0730	3958	1923
1.0740	3962	1919
1.0750	3966	1915
1.0760	3970	1912
1.0770	3973	1908
1.0780	3977	1904
1.0790	**3981**	**1900**
1.0800	3984	1897
1.0810	3988	1893
1.0820	3992	1889
1.0830	3995	1886
1.0840	3999	1882

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

1.0850	4003	1878
1.0860	4006	1875
1.0870	4010	1871
1.0880	4014	1867
1.0890	4017	1864
1.0900	4021	1860
1.0910	4025	1856
1.0920	4029	1852
1.0930	4032	1849
1.0940	4036	1845
1.0950	4040	1841
1.0960	4043	1838
1.0970	4047	1834
1.0980	4051	1830
1.0990	4054	1827
1.1000	4058	1823
1.1010	4062	1819
1.1020	4065	1816
1.1030	4069	1812
1.1040	4073	1808
1.1050	4077	1805
1.1060	4080	1801
1.1063	**4081**	**1800**
1.1070	4084	1797
1.1080	4088	1793
1.1090	4091	1790
1.1100	4095	1786
1.1110	4099	1782
1.1120	4102	1779
1.1130	4106	1775
1.1140	4110	1771
1.1150	4113	1768
1.1160	4117	1764
1.1170	4121	1760
1.1180	4124	1757
1.1190	4128	1753
1.1200	4132	1749
1.1210	4136	1745
1.1220	4139	1742
1.1230	4143	1738
1.1240	4147	1734
1.1250	4150	1731
1.1260	4154	1727
1.1270	4158	1723
1.1280	4161	1720
1.1290	4165	1716
1.1300	4169	1712

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

1.1310	4172	1709
1.1320	4176	1705
1.1330	4180	1701
1.1334	**4181**	**1700**
1.1340	4184	1698
1.1350	4187	1694
1.1360	4191	1690
1.1370	4195	1686
1.1380	4198	1683
1.1390	4202	1679
1.1400	4206	1675
1.1410	4209	1672
1.1420	4213	1668
1.1430	4217	1664
1.1440	4220	1661
1.1450	4224	1657
1.1460	4228	1653
1.1470	4231	1650
1.1480	4235	1646
1.1490	4239	1642
1.1500	4243	1639
1.1510	4246	1635
1.1520	4250	1631
1.1530	4254	1627
1.1540	4257	1624
1.1550	4261	1620
1.1560	4265	1616
1.1570	4268	1613
1.1580	4272	1609
1.1590	4276	1605
1.1600	4279	1602
1.1605	**4281**	**1600**
1.1610	4283	1598
1.1620	4287	1594
1.1630	4290	1591
1.1640	4294	1587
1.1650	4298	1583
1.1660	4302	1579
1.1670	4305	1576
1.1680	4309	1572
1.1690	4313	1568
1.1700	4316	1565
1.1710	4320	1561
1.1720	4324	1557
1.1730	4327	1554
1.1740	4331	1550
1.1750	4335	1546

TABLE VI-6

MASIP vs. Waste Stream Specific Gravity

1.1760	4338	1543
1.1770	4342	1539
1.1780	4346	1535
1.1790	4350	1532
1.1800	4353	1528
1.1810	4357	1524
1.1820	4361	1520
1.1830	4364	1517
1.1840	4368	1513
1.1850	4372	1509
1.1860	4375	1506
1.1870	4379	1502
1.1880	4383	1498
1.1890	4386	1495
1.1900	4390	1491
1.1910	4394	1487
1.1920	4397	1484
1.1930	4401	1480
1.1940	4405	1476
1.1950	4409	1472
1.1960	4412	1469
1.1970	4416	1465
1.1980	4420	1461
1.1990	4423	1458
1.2000	**4427**	**1454**

1. MSIP = Fracture Pressure - Hydrostatic Head - Safety Factor

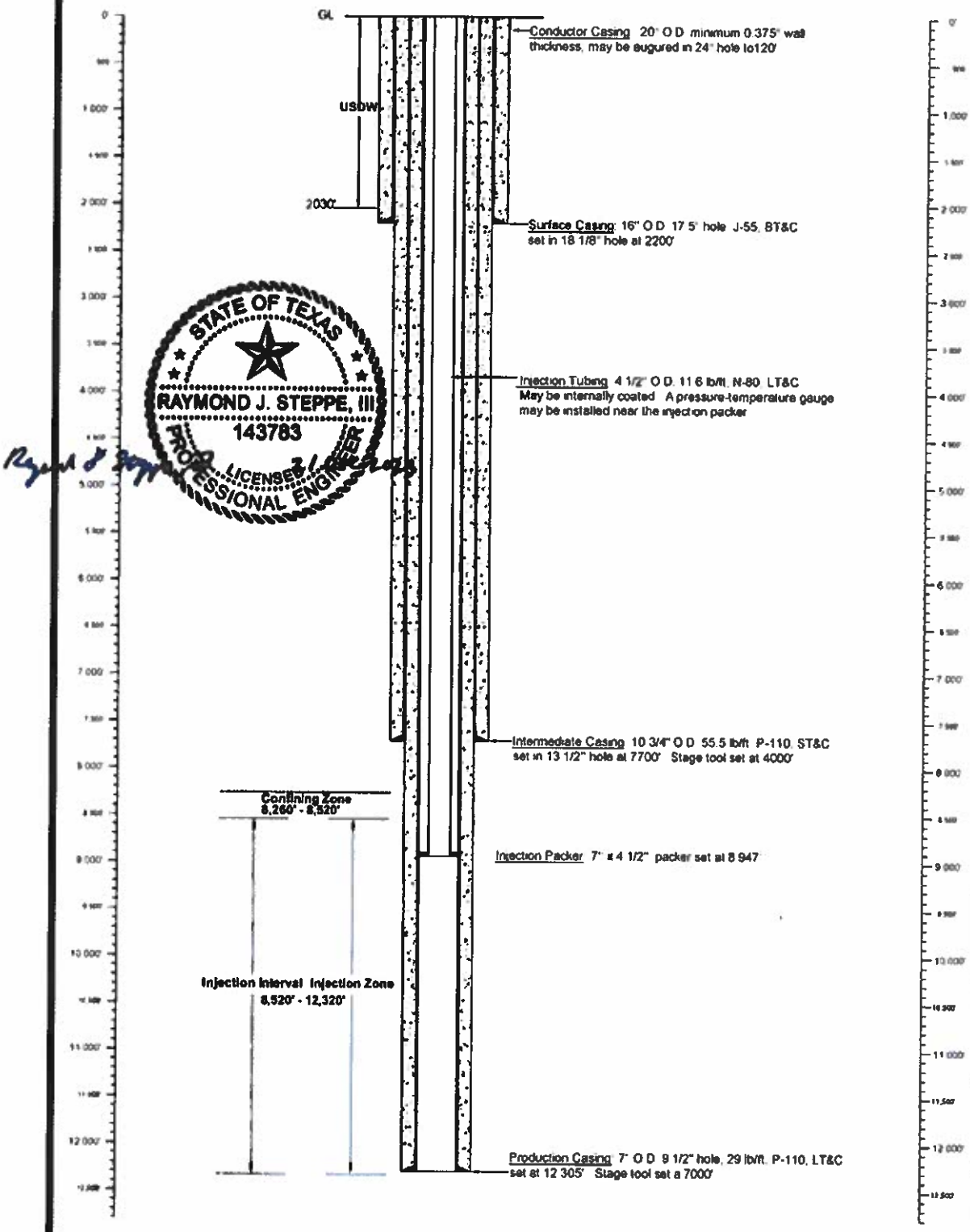
Fracture Pressure = 0.702 psi/ft x 8,520 ft.
Hydrostatic Head = 8,520 ft x Specific Gravity x 0.433 psi/ft
Safety Factor = 100 psi

TABLE VI-7
WASTE MANAGEMENT UNITS

UNIT NAME	DESCRIPTION
T-300	Above ground storage tank, Injection Holding Tanks Individual Tank: 31,500 gal (750 bbls) Total Capacity: 252,000 gal (6000 bbls)
T-310	
T-320	
T-330	
T-340	
T-350	
T-360	
T-370	
T-260	Product Storage Tank 12,500 gal
SC-100	Secondary Containment Sump
UB-100	Unloading Bay Sump
UB-110	Unloading Bay Sump

FIGURES

NOTE: Depths are BGL in feet



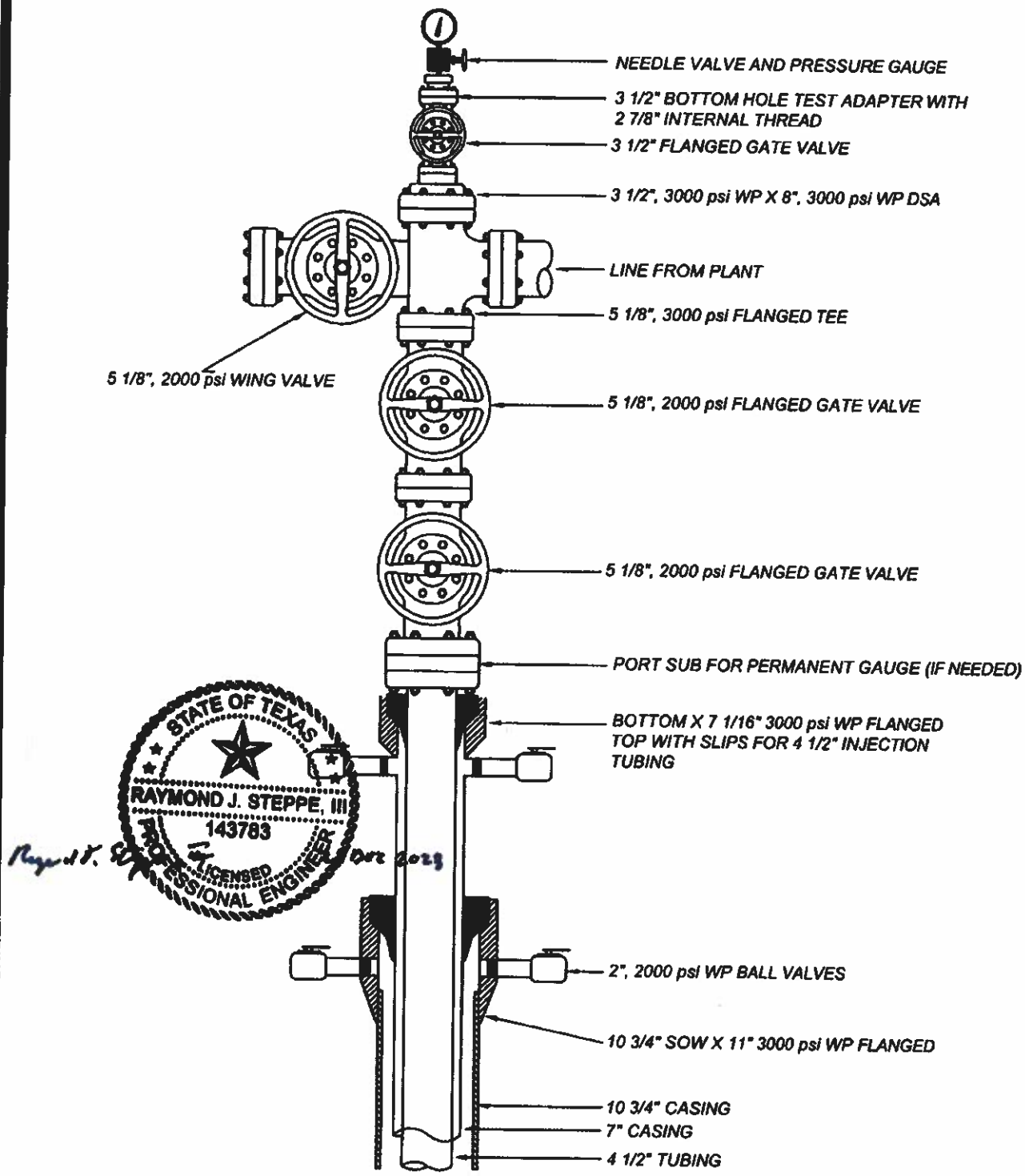
* See https://www.sec.gov/Archives/edgar/data/1060391/000106039120000016/exhibit211_subsidiarie.htm for listing of Republic subsidiaries and affiliates

WSP USA Inc.
16200 Park Row, Ste. 200
Houston, TX 77084
TEL. (281) 589-5900

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

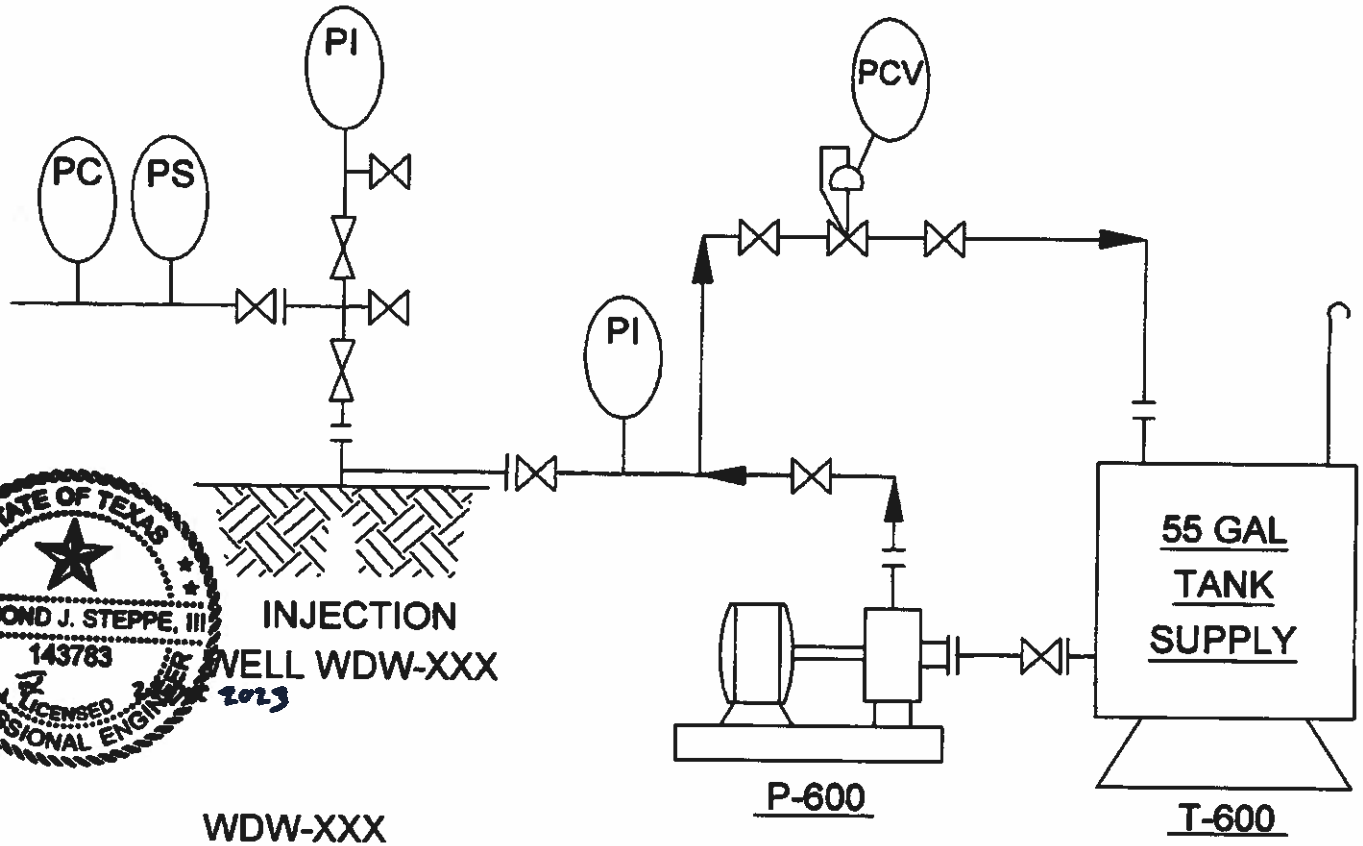
INJECTION WELL NO. 1 (IW-1) PROPOSED BELOW GROUND DETAIL

Drawn: WDD	Checked: JHL	Approved: RJS	Date: 12/20/2023	Scale: Above	Job No. 192128M	Figure No. VI-1



WSP	WSP USA Energy Storage Services, Inc. 16200 Park Row, Ste. 200 Houston, TX 77084 TEL: (281) 589-5900	**NORTH TEXAS INDUSTRIAL FACILITY HILL COUNTY, TEXAS**

INJECTION WELL NO. 1 (IW-1) PROPOSED WELLHEAD SCHEMATIC					Job No. 192128M
Drawn: WDD	Checked: JHL	Approved: RJS	Date: 11/08/2023	Scale: NONE	Figure No. VI-2



STATE OF TEXAS
RAYMOND J. STEPPE, III
143783
LICENSED
PROFESSIONAL ENGINEER
2023

WDW-XXX
WASTE WATER
DISPOSAL WELL

P-600
ANNULUS CHARGE PUMP

T-600
ANNULUS SUPPLY TANK

LEGEND:

PC = Pressure Controller
PS = Pressure Switch
PI = Pressure Indicator
PCV = Pressure Control Valve
⋈ = Valve

Source: RIES Itasca Facility Simple Piping and Instrumentation Drawing

WSP USA Energy Storage Services, Inc.
16200 Park Row, Ste 200
Houston, Texas 77084
TEL. (281) 589-5900

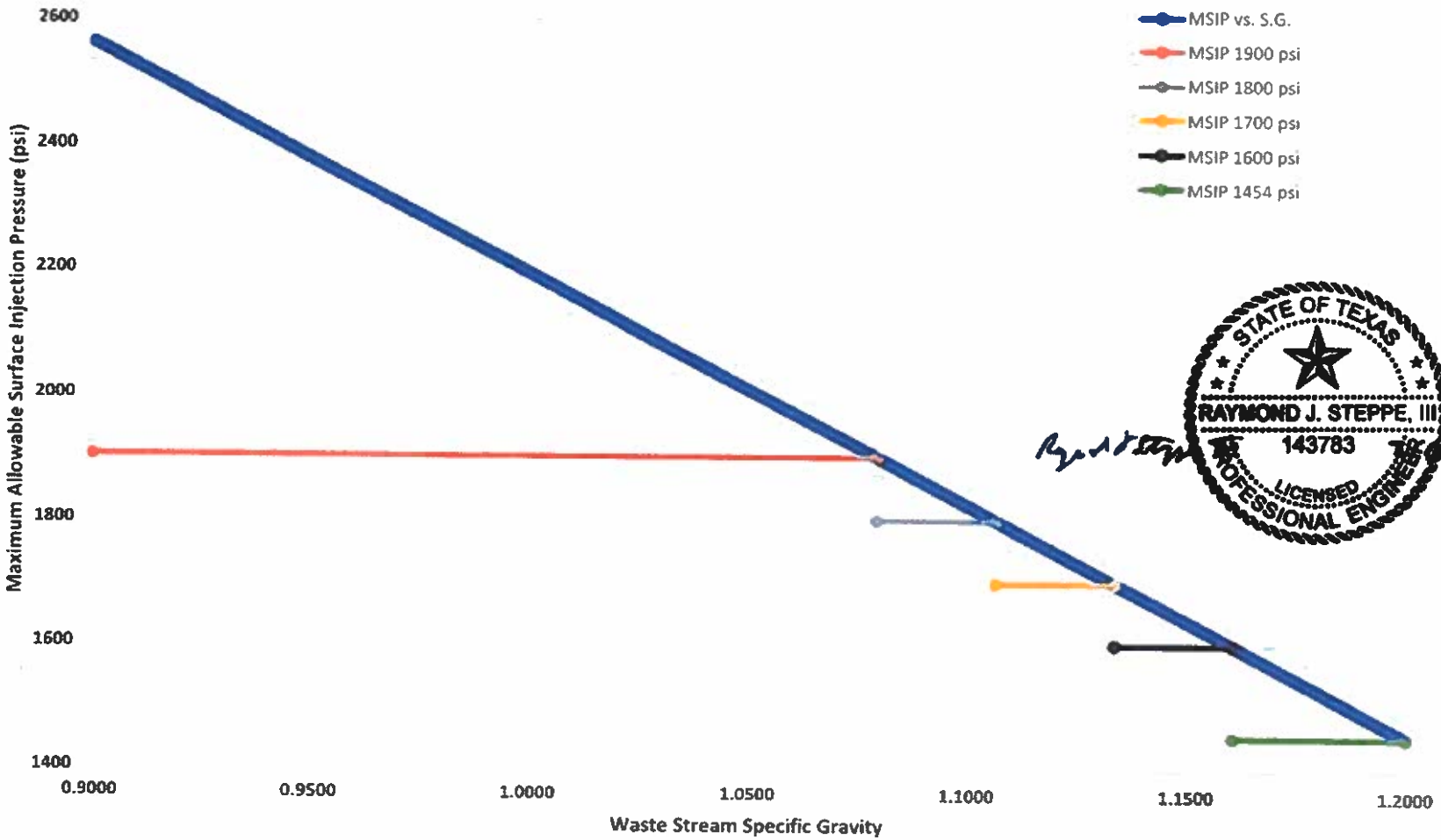
NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

WELL ANNULUS MONITORING SYSTEM

Drawn: WDD	Checked: JHL	Approved: RJS	Date: 12/20/2023	Scale: None	Job No. 192128M Figure No. VI–3

FIGURE VI-4

MSIP vs. Waste Stream Specific Gravity
North Texas Industrial Facility



STATE OF TEXAS
RAYMOND J. STEPPE, III
143783
LICENSED
PROFESSIONAL ENGINEER
Dec 2023

APPENDICES

APPENDIX

VI-1 Drilling and Completion Procedure

APPENDIX VI-1
DRILLING AND COMPLETION PROCEDURE
TYPICAL CLASS I NON-HAZARDOUS DISPOSAL WELL

1. Survey and stake the location as required.
2. Level and board the location as required.
3. Install mud tanks to accommodate both freshwater and saltwater mud systems. Prepare the well cellar providing required spill containment.
4. Auger the 20 inch OD conductor pipe in 24 inch hole to approximately 120 feet.
5. Excavate a rathole and mousehole with an auger.
6. Move in and rig up the drilling rig and related equipment.
7. Build a spud mud of 8.4 – 8.7 ppg for drilling the surface hole.
8. Drill a 18 1/8 inch hole to approximately 2200 feet (approximately 170 feet below the USDW) using the spud mud. Conduct inclination surveys every 500 feet and at total depth.

   NOTE: If circulation is lost while drilling the 18 1/8 inch surface hole, lost-circulation pills will be pumped as needed to regain circulation. Lost circulation will be controlled with cottonseed hull blends or other recommended lost-circulation material additions as hole conditions warrant.
9. Circulate and condition the hole and mud for logging.
10. Run a dual induction, formation density, compensated neutron, natural gamma ray, spontaneous potential and caliper log from total depth to the base of the conductor casing. Determine the base of the USDW from the logs and assure the casing shoe will be at least 100 feet below the depth of the USDW.
11. Condition the hole and mud for running the 16 inch surface casing.
12. Run the 16 inch, 75 lb/ft, J-55, BT&C surface casing and set the casing at approximately 2200 feet. Use a float shoe and float collar for cementing operation. Strategically place bow spring centralizers on the 16 inch casing (placement and number will depend on the casing setting depth and hole conditions). Casing specifications for the 16 inch, 75 lb/ft, J-55, BT&C casing are as follows:

    Wall ..... 0.438 inches
    ID ..... 15.124 inches
    Drift ..... 14.936 inches
    Coupling OD ..... 17 inches
    Collapse ..... 1,020 psi
    Burst ..... 2,630 psi
    Pipe Body Strength ..... 1,178,000 pounds
    Joint Strength ..... 1,200,000 pounds
    Capacity ..... 0.2222 barrels/ft
13. Cement the 16 inch surface casing from total depth to the surface with a lead slurry consisting of a light-weight cement blend and tail slurry consisting of a premium cement blend (actual cement volume will be based upon hole size calculated from caliper tool, plus 50% excess, 20% excess minimum is Class I requirement).

14. Run a temperature survey log from total depth to the surface after an eight-hour wait-on-cement (WOC) period. Bring in mudlogging crew.
15. Nipple up bell nipple to 16 inch and 21-1/4 inch annular, 3000 psi and pressure test to 1,000 psi for 30 minutes. Mix mud system to 8.4 – 9.0 ppg.
16. Make up a 13 ½ inch bit and bottom-hole assembly and trip in the hole to the 16 inch casing shoe.
17. Test the 16 inch surface casing to 1,000 psi for a minimum of 30 minutes. Monitor and record the test on a pressure chart.
18. Drill out the 16 inch casing shoe and drill a 13 ½ inch hole to approximately 7,700 feet. Obtain inclination surveys at 500-foot intervals. Maintain a low-solids drilling fluid system using the solids-control equipment.
19. Move in and rig up an electric wireline unit. Perform dual induction, gamma ray, spontaneous potential, caliper, compensated neutron, formation density and fracture identification logging from total depth to the base of the 16 inch surface casing. Conduct cement bond/VDL on the 16 inch surface casing.
20. Condition the hole and mud for running the 10¾ inch casing. Run the 10¾ inch casing string as follows: 7,700 feet of 10¾ inch, 55.5 lb/ft, P-110, ST&C with stage collar set at 4000 feet. Use a packoff float shoe on the bottom joint. Centralizers will be strategically positioned on the 10¾ inch casing for cement job optimization. The 10¾ inch, 55.5 lb/ft, P-110, ST&C casing specifications are as follows:

    Wall ..... 0.495 inches
    I.D. ..... 9.76 inches
    Drift ..... 9.604 inches
    Coupling O.D. ..... 11.75 inches
    Collapse ..... 4,610 psi
    Burst ..... 8,860 psi
    Pipe Body Strength ..... 1,754,000 pounds
    Joint Strength ..... 1,202,000 pounds
    Capacity ..... 0.0925 barrels/ft

21. Cement the 10¾ inch casing from total depth to the surface in two stages. The first stage will be cemented from total depth at 7,700 feet to the stage collar at 4,000 feet. A light-weight cement blend will be used as the lead slurry and a premium cement blend will be used as the tail slurry. Cement volumes will be determined after the open hole caliper log interpretations. A 20% excess volume will be added to the measured cement volume. Wait on the cement at least 12 hours.

22. Open stage tool and conduct second stage of cement job from 4000 feet to surface. A light-weight cement blend will be used as the lead slurry and a premium cement blend will be used as the tail slurry. Cement volumes will be determined after the open hole caliper log interpretations. A 20% excess volume will be added to the measured cement volume. Wait on cement. Run a temperature log after approximately eight hours. Conduct top-out cement job if necessary to bring cement to surface.
23. Remove the 21-1/4 inch annular and 16 inch bell nipple and install a 10¾ inch × 11 inch, 3000-psi slip-on-weld flange.
24. Nipple up the blowout preventers and pressure test to 250 psi low and 1,500 psi high for 30 minutes. Mix mud system to 9.5 – 10.0 ppg.

25. Make up the 9 ½ inch bit and required bottom-hole assembly and trip in the hole to 7,680 feet (20 feet above base of protection casing). Pressure test the 10¾ inch casing to 1,500 psi for a minimum of 30 minutes. Monitor and record the test on a pressure chart.
26. Drill out the float shoe with 9 ½ inch bit. Obtain inclination surveys at 500-foot intervals. Maintain a low-solids drilling fluid system using the solids-control equipment. If circulation occurs, an attempt will be made to dry drill the remaining 9 ½ inch hole.
27. Circulate and condition the hole and drilling fluid for coring the Confining Zone.
28. Pull out of the hole with the 9 ½ inch bit and bottom-hole assembly. Pick up an 8¾ inch core bit with a 4 inch x 30-foot core barrel.
29. Trip in the hole with the coring assembly and cut one core in the Confining Zone shale from approximately 8,350 to 8,380 feet.
30. Pull out of the hole with the coring assembly and lay down the recovered core. Prepare the core for shipment to a core laboratory for analyses.
31. Pick up the 9 ½ inch bit and bottom-hole assembly. Trip in the hole to approximately 8,350 feet and ream (if necessary) the open hole to approximately 8,380 feet (end of the 8¾ inch cored hole).
32. Drill a 9 ½ inch hole to approximately 9,730 feet (core point in the Injection Interval).
33. Circulate and condition the hole and drilling fluid for coring the Injection Zone.
34. Pull out of the hole with the 9 ½ inch bit and bottom-hole assembly. Pick up an 8¾ inch core bit with a 4 inch x 30-foot core barrel.
35. Trip in the hole with the coring assembly and cut one core in the Injection Zone (Ellenburger) from approximately 9,730 to 9,760 feet.
36. Pull out of the hole with the coring assembly and lay down the recovered core. Prepare the core for shipment to a core laboratory for analyses.
37. Pick up the 9 ½ inch bit and bottom-hole assembly. Trip in the hole to approximately 9,730 feet and ream (if necessary) the open hole to approximately 9,760 feet (end of the 8¾ inch cored hole).
38. Drill a 9 ½ inch hole to approximately 11,230 feet (core point in the Injection Zone).
39. Circulate and condition the hole and drilling fluid for coring the Injection Zone.
40. Pull out of the hole with the 9 ½ inch bit and bottom-hole assembly. Pick up an 8¾ inch core bit with a 4 inch x 30-foot core barrel.
41. Trip in the hole with the coring assembly and cut one core in the Injection Zone (Ellenburger) from approximately 11,230 to 11,260 feet.
42. Pull out of the hole with the coring assembly and lay down the recovered core. Prepare the core for shipment to a core laboratory for analyses.
43. Pick up the 9 ½ inch bit and bottom-hole assembly. Trip in the hole to approximately 11,230 feet and ream (if necessary) the open hole to approximately 11,260 feet (end of the 8¾ inch cored hole).
44. Drill a 9 ½ inch hole to total depth at approximately 12,400 feet. Circulate and condition the hole and drilling fluid for logging.
45. Move in and rig up an electric wireline unit. Perform a dual laterolog, gamma ray, spontaneous potential, caliper, formation density, formation fracture finder log and compensated neutron from total depth to the bottom of the 10¾ inch protection casing. Conduct cement bond/VDL log on the 10 ¾ inch intermediate casing.
46. Pick up the 9 ½ inch bit and bottom-hole assembly and trip in the hole to approximately 12,305 feet.
47. Condition the hole and mud for running the 7 inch casing. Run the 7 inch casing string as follows: 12,305 feet of 7 inch, 29 lb/ft, P-110, LT&C with stage collar set at 7000 feet. Use a packoff float shoe

on the bottom joint. Centralizers will be strategically positioned on the 7 inch casing for cement job optimization. The 7 inch, 29 lb/ft, P-110, LT&C casing specifications are as follows:

Wall	0.408 inches
I.D.	6.184 inches
Drift	6.059 inches
Coupling O.D.	7.656 inches
Collapse	8,530 psi
Burst	11,220 psi
Pipe Body Strength	929,000 pounds
Joint Strength	797,000 pounds
Capacity	0.0371 barrels/ft

48. Cement the 7 inch casing from total depth to the surface in two stages. The first stage will be cemented from total depth at 12,305 feet to the stage collar at 7,000 feet. A light-weight cement blend will be used as the lead slurry and a premium cement blend will be used as the tail slurry. Cement volumes will be determined after the open hole caliper log interpretations. A 20% excess volume will be added to the measured cement volume. Wait on the cement at least 12 hours.
49. Open stage tool and conduct second stage of cement job from 7000 feet to surface. A light-weight cement blend will be used as the lead slurry and a premium cement blend will be used as the tail slurry. Cement volumes will be determined after the open hole caliper log interpretations. A 20% excess volume will be added to the measured cement volume. Wait on cement. Run a temperature log after approximately eight hours. Conduct top-out cement job if necessary to bring cement to surface.

50. Rig down the drilling rig. Release the rig and related equipment.

RECOMMENDED TESTING AND COMPLETION

The following are the recommended testing and completion procedures:

1. Move in a workover rig and pick up 2 7/8 inch EUE workstring. Using a power swivel, drill out the stage tool and shoe track. Conduct a pressure test to 1500 psig.
2. Pull out of the hole with the workstring. Rig up wireline.
3. Run a casing inspection (baseline survey) and cement bond/variable density log to 12,305 feet on the 7 inch production casing.
4. Perforate the Ellenburger formation in the Injection Interval at selected intervals, starting from the bottom to the top.
5. Move in a workover rig and pick up a retrievable packer on 2⅞ inch EUE workstring. Trip in the hole to 20 ft above the perforated interval and set the retrievable packer.
6. Rig up a coiled tubing nitrogen unit to recover approximately 500 barrels of water from the open hole. Catch two five-gallon samples of clean formation fluid if the interval can be produced naturally without stimulation.
7. Conduct an injection profile survey, using spinner survey logging equipment.
8. Run an injectivity test with a spinner survey as follows using filtered water:
   a. Make at least two static passes with the spinner survey in the injection interval.
   b. Commence injection at predetermined rates and perform a spinner survey at each rate through the injection interval.
   c. Conduct stationary surveys at selected depths, while pumping at each depth using the same rates as in Step No. 5b above.
9. Rig down and release the spinner survey equipment.
   NOTE: An acid stimulation will be performed if necessary.
10. Trip out of the hole with the retrievable packer. Lay down work string.
11. Connect a 7 inch × 4 ½ inch packer to 4 ½ inch, 11.6 lb/ft, N-80, LT&C injection tubing and run in the well to 8,947 feet.
12. Space out the tubing, place corrosion inhibited packer fluid in the annulus, set the packer, and set the slips on the landing joint. The injection tubing will be set in compression.
13. Conduct an annular pressure test in accordance with TCEQ requirements.
14. Rig down and move out the workover rig and auxiliary equipment.
15. Rig up a wireline unit, mast truck, and pump truck and conduct a pressure falloff test in accordance with TCEQ guidelines.
16. Run a radioactive tracer survey in accordance with TCEQ guidelines. Conduct an annulus pressure test to 2000 psig (100 psig above permitted maximum surface injection pressure).
17. Rig down and move out the wireline equipment. Prepare a completion report.

APPENDIX

VI-2 Cementing Company Recommendations

HALLIBURTON

WSP USA INC -EBUS
DONOTMAIL-16200 PARK ROW STE 200
HOUSTON, TX, 77084
US

ITASCA LANDFILL CLASS I

HILL County, TX, US

Cementing Cost Estimate

Proposal 488792 - Version 1.0
October 16, 2023

Submitted by:
Timothy Pohl
3000 N Sam Houston Pkwy E
Houston
TX - 770323219
USA

HALLIBURTON

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Halliburton appreciates the opportunity to present this cost estimate and looks forward to being of service to you.

1 Foreword

Enclosed is our cost estimate for cementing the casing strings in the referenced well. The information in this cost estimate includes well data, calculations, materials requirements, and cost estimates. This cost estimate is based on information from our field personnel and previous cementing services in the area.

The selection and use of non-Halliburton plugs and casing attachments often compromises the holistic approach and may jeopardize the overall objective for effective zonal isolation. Furthermore, Halliburton is not involved in the design, manufacture or use of plugs and casing attachments supplied by other manufacturers and assumes no liability for their installation and operation. For this reason we recommend Halliburton plugs and casing attachments be used when Halliburton performs any zonal isolation operation.

Halliburton Energy Services recognizes the importance of meeting society's needs for health, safety, and protection of the environment. It is our intention to proactively work with employees, customers, the public, governments, and others to use natural resources in an environmentally sound manner while protecting the health, safety, and environmental processes while supplying high quality products and services to our customers.

We appreciate the opportunity to present this cost estimate for your consideration and we look forward to being of service to you. Our Services for your well will be coordinated through the Service Center listed below. If you require any additional information or additional designs, please feel free to contact myself or our field representative listed below.

2 Service Center Contacts

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3 16" Surface Casing

3.1 Job Information 16" Surface Casing

Job Criticality Status: GREEN
Well Name: ITASCA LANDFILL Well #: CLASS I

20" Conductor	0 - 200 ft (MD)
Outer Diameter	20 in
Inner Diameter	19.25 in
18 1/8" Open Hole	200 - 2,200 ft (MD)
Inner Diameter	18.125 in
Excess Factor	50 %
16" Surface Casing	0 - 2,200 ft (MD)
Outer Diameter	16 in
Inner Diameter	15.25 in
Linear Weight	65 lbm/ft
Shoe Joint Length	40 ft
Mud Type	Water Based Mud
Mud Weight	9 lbm/gal

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3.2 Estimated Calculations 16" Surface Casing

Stage 1

CEMENT: (1,760 ft fill)

1,560 ft * 0.3955 ft3/ft * 50 %	= 925.5 ft3
200 ft * 0.6248 ft3/ft * 0 %	= 124.97 ft3
Lead Cement	= 1,050.47 ft3
	= 190.4 bbl
Total Lead	= 450.11 sack

CEMENT: (440 ft fill)

440 ft * 0.3955 ft3/ft * 50 %	= 261.04 ft3
Tail Cement	= 261.04 ft3
	= 48.2 bbl

Shoe Joint Volume: (40 ft fill)

40 ft * 1.2684 ft3/ft	= 50.74 ft3
	= 9 bbl

Tail plus shoe joint	= 321.15 ft3
	= 57.2 bbl
Total Tail	= 249.93 sack

Total Pipe Capacity:

200 ft * 1.2684 ft3/ft	= 253.69 ft3
2,000 ft * 1.2684 ft3/ft	= 2,536.86 ft3
	= 497 bbl

Displacement Volume to Shoe Joint:

Capacity of Pipe - Shoe Joint	= 497 bbl - 9 bbl
	= 488 bbl

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3.3 Job Volume Estimates 16" Surface Casing

Stage 1

Fluid 1: Fresh Water

Fresh Water	Fluid Density:	8.33 lbm/gal
	Volume:	**50 bbl**

Fluid 2: Lead Slurry

EXTENDACEM (TM) SYSTEM	Fluid Weight:	12 lbm/gal
0.2 % HR-7	Slurry Yield:	2.375 ft3/sack
13.76 Gal/sk FRESH WATER	Total Mixing Fluid:	13.76 Gal/sack
	Calculated Volume:	**187.1 bbl**
	Proposed Volume:	**190.4 bbl**
	Top Of Fluid:	0 ft
	Calculated Fill:	1,760 ft
	Calculated sack:	442.3 sack
	Proposed sack:	450 sack

Fluid 3: Tail Slurry

HALCEM (TM) SYSTEM	Fluid Weight:	15 lbm/gal
0.1 % HR-7	Slurry Yield:	1.285 ft3/sack
6.01 Gal/sk FRESH WATER	Total Mixing Fluid:	6.01 Gal/sack
	Calculated Volume:	**55.5 bbl**
	Proposed Volume:	**57.2 bbl**
	Top Of Fluid:	1,760 ft
	Calculated Fill:	440 ft
	Calculated sack:	242.63 sack
	Proposed sack:	250 sack

Fluid 4: Water Based Mud

Water Based Mud Displacement	Fluid Density:	9 lbm/gal
	Volume:	**488 bbl**

Fluid 5: Top Off Annulus

SWIFTCEM (TM) SYSTEM	Fluid Weight:	14.8 lbm/gal
2 % Calcium Chloride, Pellet	Slurry Yield:	1.356 ft3/sack
6.51 Gal/sk FRESH WATER	Total Mixing Fluid:	6.51 Gal/sack
	Calculated Volume:	**24.1 bbl**
	Proposed Volume:	**24.1 bbl**
	Calculated sack:	0 sack
	Proposed sack:	100 sack

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3.4 Volume Estimate Table 16" Surface Casing

Calculations are used for volume estimation. Well conditions will dictate final cement job design.

Stage 1

Fluid #	Fluid Type	Fluid Name	Surface Density lbm/gal	Estimated Avg Rate	Downhole Volume
1	MUD	Fresh Water	8.33		50 bbl
2	CEMENT	Lead Cement	12		450 sack
3	CEMENT	Tail Cement	15		250 sack
4	MUD	Water Based Mud Displacement	9		488 bbl
5	CEMENT	TOP OUT	14.8		100 sack

NOTE: These slurries and spacers will require lab testing. The additives and concentrations are estimates based on field experience in the area and may need to be modified prior to the job. The proposed spacer is designed to be generally compatible with water base mud systems. Compatibility testing with field mud samples used may indicate changes in the additive package and the related costs.

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3.5 Cost Estimate

Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
7521	**CMT SURFACE CASING BOM** *7521*	1.00	JOB	0.00	0.00
Cementing Services & Equipment					
1	ZI-MILEAGE FROM NEAREST HES BASE,/UNIT Number of Units	480.00 1	MI	USD 9.79/ 1 MI	4,699.20
2	MILEAGE FOR CEMENTING CREW Number of Units	480.00 1	MI	USD 5.76/ 1 MI	2,764.80
16091	ZI - PUMPING CHARGE FEET/METERS (FT/M) DEPTH	1.00 FT 2200	EA	USD 7,095.00/ 1 EA	7,095.00
141	RCM II W/ADC,/JOB,ZI ENTER FEET\METER\JOB\DAY NUMBER OF JOBS NUMBER OF UNITS	1.00 JOB 1 1	JOB	USD 1,990.00/ 1 JOB	1,990.00
132	PORT. DAS W/CEMWIN;ACQUIRE W/HES, ZI NUMBER OF DAYS	1.00 1	JOB	USD 1,649.00/ 1 JOB	1,649.00
119534	SUCTION HOSE, 4"/FT W/HES,PER JOB ZI NUMBER OF JOBS	100.00 1	FT	USD 4.40/ 1 FT	440.00
14089	PUP TRAILER,NON-ACID MATLS,0-8 HRS,ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN HOURS (MIN8)	1.00 H 8	EA	USD 822.00/ 1 EA	822.00
74038	ZI PLUG CONTAINER RENTAL-1ST DAY HR/DAY/WEEK/MTH/YEAR/JOB/RUN DAYS OR FRACTION (MIN1)	1.00 DAY 1	EA	USD 1,322.00/ 1 EA	1,322.00
90	ZI QUICK LATCH ATTACHMENT INCHES/MILLIMETERS (IN/MM) SIZE IN INCHES/MILLIMETER	1.00 IN 13.375	JOB	USD 616.00/ 1 JOB	616.00
11941	FIELD STORAGE BIN DEL & RETURN, ZI Number of Units	480.00 1	MI	USD 9.79/ 1 MI	4,699.20
16115	FIELD STORAGE BIN ON SITE >8 HRS,DAY,ZI DAYS OR PARTIAL DAY(WHOLE NO.)	1.00 1	EA	USD 1,344.00/ 1 EA	1,344.00
	SubTotal				**27,441.20**
Cement Materials					
452981	CMT, ExtendaCem (TM) system	450.00	SK	0.00	20,591.16
100005055	CHEM, HR-7 Cement Retarder *HR-7*	82.00	LB	USD 5.88/ 1 LB	289.30
452986	CMT, HalCem (TM) system	250.00	SK	0.00	6,486.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	24.00	LB	USD 5.88/ 1 LB	84.67
76400	MILEAGE,CMT MTLS DEL/RET MIN NUMBER OF TONS	240.00 38.735	MI	USD 3.35/ 1 MI	18,685.76
3965	HANDLE&DUMP SVC CHRG, CMT&ADDITIVES,ZI Unit of Measurement NUMBER OF EACH	872.00 EA 1	CF	USD 5.49/ 1 CF	2,872.37
	SubTotal				**49,009.26**
Non-Discounted Items					

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Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
7	ENVIRONMENTAL CHARGE,/JOB,ZI	2.00	JOB	USD 134.00/ 1 JOB	268.00
11881	OVERWEIGHT PERMIT FEE-CEMENTING	7.00	EA	USD 60.00/ 1 EA	420.00
452990	CMT, SwiftCem (TM) system	100.00	SK	0.00	3,241.80
	Total Gross Amount				**114,733.50**
	Total Item Discounts				**34,353.24**
	Total Net Amount	**USD**			**80,380.26**

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Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
Optional Charge					
16092	ADDITIONAL HOURS (PUMPING EQUIPMENT), ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN HOURS	1.00 H 1	EA	USD 1,139.00/ 1 EA	**1,139.00**
802332	CMT STBY UNIT 1ST 8 HR CSG JOB	1.00	UN	USD 10,000.00/ 1 UN	**10,000.00**
803106	CMT STBY UNIT CSG JOB ADDL HR >BASE HR/DAY/WEEK/MTH/YEAR/JOB/RUN TOTAL NUMBER	1.00 JOB 1	EA	USD 1,139.00/ 1 EA	**1,139.00**
756221	CMT RNTL BULK TRUCK ONSITE 0-8 HRS	1.00	EA	USD 1,568.00/ 1 EA	**1,568.00**
526969	CMT, STx Booster Pump-Skid, per day	1.00	EA	USD 2,484.00/ 1 EA	**2,484.00**
143826	Circulating Iron Rental & Delivery, ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN TOTAL NUMBER	1.00 JOB 1	EA	USD 2,500.00/ 1 EA	**1,750.00**
3	ZI-DERRICK CHARGE	1.00	EA	USD 987.00/ 1 EA	**690.90**
100008028	CHEM, SUGAR,GRANULATED, 50LB BAG	50.00	LB	USD 6.96/ 1 LB	**243.60**
53	1" PIPE FOR CEMENTING TOP OUTSIDE NUMBER OF DAYS	100.00 1	EA	USD 4.00/ 1 EA	**400.00**

Primary Plant: Bossier City, LA, USA
Secondary Plant: Bossier City, LA, USA
Price Book Ref: 29 - SOUTHEAST
Price Date: 10/01/23

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4 10 3/4" DV Intermediate Casing

4.1 Job Information 10 3/4" DV Intermediate Casing

Job Criticality Status: GREEN
Well Name: ITASCA LANDFILL Well #: CLASS I

16" Surface Casing	0 - 2,200 ft (MD)
Outer Diameter	16 in
Inner Diameter	15.25 in
Linear Weight	65 lbm/ft
13 1/2" Open Hole	2,200 - 7,700 ft (MD)
Inner Diameter	13.5 in
Excess Factor	20 %
10 3/4" Intermediate Casing	0 - 7,700 ft (MD)
Outer Diameter	10.75 in
Inner Diameter	9.76 in
Linear Weight	55.5 lbm/ft
Shoe Joint Length	80 ft
Multiple Stage Cementer	4,000 ft (MD)
Mud Type	Water Based Mud
Mud Weight	11 lbm/gal

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4.2 Estimated Calculations 10 3/4" DV Intermediate Casing

Stage 1

SPACER: (643 ft fill)

643 ft * 0.3637 ft3/ft * 20 %	= 280.73 ft3
Total Spacer	= 280.73 ft3
	= 50 bbl

CEMENT: (2,200 ft fill)

2,200 ft * 0.3637 ft3/ft * 20 %	= 960.23 ft3
Lead Cement	= 960.23 ft3
	= 171.5 bbl
Total Lead	= 590.01 sack

CEMENT: (1,500 ft fill)

1,500 ft * 0.3637 ft3/ft * 20 %	= 654.7 ft3
Tail Cement	= 654.7 ft3
	= 116.7 bbl

Shoe Joint Volume: (80 ft fill)

80 ft * 0.5195 ft3/ft	= 41.56 ft3
	= 7.4 bbl

Tail plus shoe joint	= 696.77 ft3
	= 124.1 bbl
Total Tail	= 635.16 sack

Total Pipe Capacity:

5,500 ft * 0.5195 ft3/ft	= 2,857.52 ft3
2,200 ft * 0.5195 ft3/ft	= 1,143.01 ft3
	= 712.5 bbl

Displacement Volume to Shoe Joint:

Capacity of Pipe - Shoe Joint	= 712.5 bbl - 7.4 bbl
	= 705.1 bbl

Stage 2

CEMENT: (2,800 ft fill)

600 ft * 0.3637 ft3/ft * 20 %	= 261.88 ft3
2,200 ft * 0.6381 ft3/ft * 0 %	= 1,403.9 ft3
Lead Cement	= 1,665.78 ft3
	= 300.1 bbl
Total Lead	= 700.02 sack

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CEMENT: (1,200 ft fill)

1,200 ft * 0.3637 ft3/ft * 20 %	= 523.76 ft3
Tail Cement	= 523.76 ft3
	= 86.4 bbl

Total Tail	= 409.84 sack

Total Pipe Capacity:

2,200 ft * 0.5195 ft3/ft	= 1,143.01 ft3
1,800 ft * 0.5195 ft3/ft	= 935.19 ft3
	= 370.1 bbl

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4.3 Job Volume Estimates 10 3/4" DV Intermediate Casing

Stage 1

Fluid 1: Water Based Spacer

12.0 lb/gal Tuned Spacer III	Fluid Density:	12 lbm/gal
35.35 gal/bbl FRESH WATER	**Volume:**	**50 bbl**
0.5 lbm/bbl FE-2		
0.1 gal/bbl D-AIR 3000L		
175.4 lbm/bbl Barite		

Fluid 2: Lead Slurry

NeoCem TM	Fluid Weight:	12.5 lbm/gal
0.5 % HR-7	Slurry Yield:	1.632 ft3/sack
8.67 Gal/sk FRESH WATER	Total Mixing Fluid:	8.67 Gal/sack
	Calculated Volume:	**171 bbl**
	Proposed Volume:	**171.5 bbl**
	Top Of Fluid:	4,000 ft
	Calculated Fill:	2,200 ft
	Calculated sack:	588.38 sack
	Proposed sack:	590 sack

Fluid 3: Tail Slurry

NeoCem TM	Fluid Weight:	14.5 lbm/gal
0.3 % HR-7	Slurry Yield:	1.097 ft3/sack
4.63 Gal/sk FRESH WATER	Total Mixing Fluid:	4.63 Gal/sack
	Calculated Volume:	**124 bbl**
	Proposed Volume:	**124.1 bbl**
	Top Of Fluid:	6,200 ft
	Calculated Fill:	1,500 ft
	Calculated sack:	634.7 sack
	Proposed sack:	635 sack

Fluid 4: Water Based Mud

Water Based Mud	Fluid Density:	11 lbm/gal
	Volume:	**705.1 bbl**

Multiple Stage Cementer 4,000(MD)

Stage 2

Fluid 1: Fresh Water

Fresh Water	Fluid Density:	8.33 lbm/gal
	Volume:	**50 bbl**

Fluid 2: Lead Slurry

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EXTENDACEM (TM) SYSTEM	Fluid Weight:	12 lbm/gal
0.2 % HR-7	Slurry Yield:	2.407 ft3/sack
14.01 Gal/sk FRESH WATER	Total Mixing Fluid:	14.01 Gal/sack
	Calculated Volume:	**296.7 bbl**
	Proposed Volume:	**300.1 bbl**
	Top Of Fluid:	0 ft
	Calculated Fill:	2,800 ft
	Calculated sack:	692.06 sack
	Proposed sack:	700 sack

Fluid 3: Tail Slurry

HALCEM (TM) SYSTEM	Fluid Weight:	15 lbm/gal
0.1 % HR-7	Slurry Yield:	1.285 ft3/sack
6.01 Gal/sk FRESH WATER	Total Mixing Fluid:	6.01 Gal/sack
	Calculated Volume:	**93.3 bbl**
	Proposed Volume:	**93.8 bbl**
	Top Of Fluid:	2,800 ft
	Calculated Fill:	1,200 ft
	Calculated sack:	407.6 sack
	Proposed sack:	410 sack

Fluid 4: Fresh Water

Fresh Water	Fluid Density:	8.33 lbm/gal
	Volume:	**370.1 bbl**

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4.4 Volume Estimate Table 10 3/4" DV Intermediate Casing

Calculations are used for volume estimation. Well conditions will dictate final cement job design.

Stage 1

Fluid #	Fluid Type	Fluid Name	Surface Density lbm/gal	Estimated Avg Rate	Downhole Volume
1	SPACER	12.0 lb/gal Tuned Spacer III	12		50 bbl
2	CEMENT	Lead Cement	12.5		171.5 bbl
3	CEMENT	Tail Cement	14.5		124.1 bbl
4	MUD	Water Based Mud	11		705.1 bbl

Stage 2

Fluid #	Fluid Type	Fluid Name	Surface Density lbm/gal	Estimated Avg Rate	Downhole Volume
1	MUD	Fresh Water	8.33		50 bbl
2	CEMENT	Lead Cement	12		700 sack
3	CEMENT	Tail Cement	15		410 sack
4	MUD	Fresh Water	8.33		370.1 bbl

NOTE: These slurries and spacers will require lab testing. The additives and concentrations are estimates based on field experience in the area and may need to be modified prior to the job. The proposed spacer is designed to be generally compatible with water base mud systems. Compatibility testing with field mud samples used may indicate changes in the additive package and the related costs.

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4.5 Cost Estimate

Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
392189	**CMT MULTIPLE STAGES BOM** ***392189***	1.00	JOB	0.00	0.00
Cementing Services & Equipment					
1	ZI-MILEAGE FROM NEAREST HES BASE,/UNIT Number of Units	480.00 1	MI	USD 9.79/ 1 MI	4,699.20
2	MILEAGE FOR CEMENTING CREW Number of Units	480.00 1	MI	USD 5.76/ 1 MI	2,764.80
16093	MSC PUMP CHARGE (1ST STAGE), ZI FEET/METERS (FT/M) DEPTH	1.00 FT 7700	EA	USD 10,733.00/ 1 EA	10,733.00
16	MULTIPLE STAGE CEMENTING Number of Units	1.00 1	STG	USD 5,055.00/ 1 STG	5,055.00
141	RCM II W/ADC,/JOB,ZI ENTER FEET\METER\JOB\DAY NUMBER OF JOBS NUMBER OF UNITS	1.00 JOB 1 1	JOB	USD 1,990.00/ 1 JOB	1,990.00
132	PORT. DAS W/CEMWIN;ACQUIRE W/HES, ZI NUMBER OF DAYS	1.00 1	JOB	USD 1,649.00/ 1 JOB	1,649.00
119534	SUCTION HOSE, 4"/FT W/HES,PER JOB ZI NUMBER OF JOBS	100.00 1	FT	USD 4.40/ 1 FT	440.00
14089	PUP TRAILER,NON-ACID MATLS,0-8 HRS,ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN HOURS (MIN8)	1.00 H 8	EA	USD 822.00/ 1 EA	822.00
74038	ZI PLUG CONTAINER RENTAL-1ST DAY HR/DAY/WEEK/MTH/YEAR/JOB/RUN DAYS OR FRACTION (MIN1)	1.00 DAY 1	EA	USD 1,322.00/ 1 EA	1,322.00
90	ZI QUICK LATCH ATTACHMENT INCHES/MILLIMETERS (IN/MM) SIZE IN INCHES/MILLIMETER	1.00 IN 10.75	JOB	USD 616.00/ 1 JOB	616.00
11941	FIELD STORAGE BIN DEL & RETURN, ZI Number of Units	480.00 1	MI	USD 9.79/ 1 MI	4,699.20
16115	FIELD STORAGE BIN ON SITE >8 HRS,DAY,ZI DAYS OR PARTIAL DAY(WHOLE NO.)	1.00 1	EA	USD 1,344.00/ 1 EA	1,344.00
	SubTotal				**36,134.20**
Cement Materials					
483826	SBM, CMT, Tuned Spacer III	50.00	BBL	USD 284.00/ 1 BBL	4,473.00
101007444	CHEM, D-AIR 3000L, 5 GAL PAIL *D-AIR 3000L*	5.00	GAL	USD 140.55/ 1 GAL	221.37
100001615	CHEM, FE-2 *FE-2*	25.00	LB	USD 5.56/ 1 LB	43.78
100003681	CHEM, BARITE, BULK *Barite*	88.00	SK	USD 31.07/ 1 SK	861.26
1012301	SBM CEM NEOCEM™ LEAD	172.00	BBL	USD 40.00/ 1 BBL	6,880.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	236.00	LB	USD 5.88/ 1 LB	437.12

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Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
984579	SBM CEM NEOCEM™ TAIL	125.00	BBL	USD 55.00/ 1 BBL	6,875.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	153.00	LB	USD 5.88/ 1 LB	283.39
452981	CMT, ExtendaCem (TM) system	700.00	SK	0.00	10,601.76
100005055	CHEM, HR-7 Cement Retarder *HR-7*	127.00	LB	USD 5.88/ 1 LB	235.23
452986	CMT, HalCem (TM) system	410.00	SK	0.00	5,584.45
100005055	CHEM, HR-7 Cement Retarder *HR-7*	39.00	LB	USD 5.88/ 1 LB	72.24
76400	MILEAGE,CMT MTLS DEL/RET MIN NUMBER OF TONS	240.00 108.551	MI	USD 3.35/ 1 MI	30,546.25
3965	HANDLE&DUMP SVC CHRG, CMT&ADDITIVES,ZI Unit of Measurement NUMBER OF EACH	2,551.00 EA 1	CF	USD 5.49/ 1 CF	5,602.00
	SubTotal				**72,716.85**
Non-Discounted Items					
7	ENVIRONMENTAL CHARGE,/JOB,ZI	3.00	JOB	USD 134.00/ 1 JOB	402.00
11881	OVERWEIGHT PERMIT FEE-CEMENTING	12.00	EA	USD 60.00/ 1 EA	720.00
	Total Gross Amount				**224,715.24**
	Total Item Discounts				**114,742.19**
	Total Net Amount	**USD**			**109,973.05**

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Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
Optional Charge					
16092	ADDITIONAL HOURS (PUMPING EQUIPMENT), ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN HOURS	1.00 H 1	EA	USD 1,139.00/ 1 EA	**1,139.00**
802332	CMT STBY UNIT 1ST 8 HR CSG JOB	1.00	UN	USD 10,000.00/ 1 UN	**10,000.00**
803106	CMT STBY UNIT CSG JOB ADDL HR >BASE HR/DAY/WEEK/MTH/YEAR/JOB/RUN TOTAL NUMBER	1.00 JOB 1	EA	USD 1,139.00/ 1 EA	**1,139.00**
526969	CMT, STx Booster Pump-Skid, per day	1.00	EA	USD 2,484.00/ 1 EA	**2,484.00**
143826	Circulating Iron Rental & Delivery, ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN TOTAL NUMBER	1.00 JOB 1	EA	USD 2,500.00/ 1 EA	**1,750.00**
3	ZI-DERRICK CHARGE	1.00	EA	USD 987.00/ 1 EA	**690.90**
756221	CMT RNTL BULK TRUCK ONSITE 0-8 HRS	1.00	EA	USD 1,568.00/ 1 EA	**1,568.00**
100008028	CHEM, SUGAR,GRANULATED, 50LB BAG	50.00	LB	USD 6.96/ 1 LB	**243.60**

Primary Plant: Bossier City, LA, USA
Secondary Plant: Bossier City, LA, USA
Price Book Ref: 29 - SOUTHEAST
Price Date: 10/01/23

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5 7" DV Production Casing

5.1 Job Information 7" DV Production Casing

Job Criticality Status: GREEN
Well Name: ITASCA LANDFILL Well #: CLASS I

10 3/4" Intermediate Casing	0 - 7,700 ft (MD)
Outer Diameter	10.75 in
Inner Diameter	9.76 in
Linear Weight	55.5 lbm/ft
9 1/2" Open Hole	7,700 - 12,305 ft (MD)
Inner Diameter	9.5 in
Excess Factor	20 %
7" Production Casing	0 - 12,305 ft (MD)
Outer Diameter	7 in
Inner Diameter	6.184 in
Linear Weight	29 lbm/ft
Shoe Joint Length	80 ft
Multiple Stage Cementer	7,000 ft (MD)

Mud Type	Water Based Mud
Mud Weight	11 lbm/gal

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5.2 Estimated Calculations 7" DV Production Casing

Stage 1

SPACER: (1,113 ft fill)

1,113 ft * 0.2523 ft3/ft * 0 %	= 280.73 ft3
Total Spacer	= 280.73 ft3
	= 50 bbl

CEMENT: (1,500 ft fill)

800 ft * 0.225 ft3/ft * 20 %	= 215.98 ft3
700 ft * 0.2523 ft3/ft * 0 %	= 176.61 ft3
Lead Cement	= 392.59 ft3
	= 69.9 bbl
Total Lead	= 240.48 sack

CEMENT: (3,805 ft fill)

3,805 ft * 0.225 ft3/ft * 20 %	= 1,027.28 ft3
Tail Cement	= 1,027.28 ft3
	= 182.9 bbl

Shoe Joint Volume: (80 ft fill)

80 ft * 0.2086 ft3/ft	= 16.69 ft3
	= 3 bbl

Tail plus shoe joint	= 1,043.75 ft3
	= 185.9 bbl
Total Tail	= 835.67 sack

Total Pipe Capacity:

7,700 ft * 0.2086 ft3/ft	= 1,606.04 ft3
4,605 ft * 0.2086 ft3/ft	= 960.5 ft3
	= 457.1 bbl

Displacement Volume to Shoe Joint:

Capacity of Pipe - Shoe Joint	= 457.1 bbl - 3 bbl
	= 454.1 bbl

Stage 2

CEMENT: (5,000 ft fill)

5,000 ft * 0.2523 ft3/ft * 0 %	= 1,261.48 ft3
Lead Cement	= 1,261.48 ft3
	= 224.7 bbl
Total Lead	= 773.04 sack

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CEMENT: (2,000 ft fill)

2,000 ft * 0.2523 ft3/ft * 0 %	= 504.59 ft3
Tail Cement	= 504.59 ft3
	= 86.9 bbl

Total Tail	= 460.12 sack

Total Pipe Capacity:

7,000 ft * 0.2086 ft3/ft	= 1,460.04 ft3
	= 260 bbl

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5.3 Job Volume Estimates 7" DV Production Casing

Stage 1

Fluid 1: Water Based Spacer

12.0 lb/gal Tuned Spacer III	Fluid Density:	12 lbm/gal
35.35 gal/bbl FRESH WATER	**Volume:**	**50 bbl**
0.5 lbm/bbl FE-2		
0.1 gal/bbl D-AIR 3000L		
175.4 lbm/bbl BARITE		

Fluid 2: Lead Slurry

NeoCem TM	Fluid Weight:	12.5 lbm/gal
0.5 % HR-7	Slurry Yield:	1.632 ft3/sack
8.67 Gal/sk FRESH WATER	Total Mixing Fluid:	8.67 Gal/sack
	Calculated Volume:	**69.9 bbl**
	Proposed Volume:	**69.9 bbl**
	Top Of Fluid:	7,000 ft
	Calculated Fill:	1,500 ft
	Calculated sack:	240.56 sack
	Proposed sack:	245 sack

Fluid 3: Tail Slurry

NeoCem TM	Fluid Weight:	14.5 lbm/gal
0.3 % HR-7	Slurry Yield:	1.249 ft3/sack
5.25 Gal/sk FRESH WATER	Total Mixing Fluid:	5.25 Gal/sack
	Calculated Volume:	**185.9 bbl**
	Proposed Volume:	**185.9 bbl**
	Top Of Fluid:	8,500 ft
	Calculated Fill:	3,805 ft
	Calculated sack:	835.84 sack
	Proposed sack:	840 sack

Fluid 4: Water Based Mud

Water Based Mud	Fluid Density:	11 lbm/gal
	Volume:	**454.1 bbl**

Multiple Stage Cementer 7,000(MD)

Stage 2

Fluid 1: Water Based Spacer

12.0 lb/gal Tuned Spacer III	Fluid Density:	12 lbm/gal
35.35 gal/bbl FRESH WATER	**Volume:**	**50 bbl**
0.5 lbm/bbl FE-2		
0.1 gal/bbl D-AIR 3000L		

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175.4 lbm/bbl BARITE

Fluid 2: Lead Slurry

NeoCem TM	Fluid Weight:	12.5 lbm/gal
0.5 % HR-7	Slurry Yield:	1.632 ft3/sack
8.67 Gal/sk FRESH WATER	Total Mixing Fluid:	8.67 Gal/sack
	Calculated Volume:	**224.7 bbl**
	Proposed Volume:	**224.7 bbl**
	Top Of Fluid:	0 ft
	Calculated Fill:	5,000 ft
	Calculated sack:	772.97 sack
	Proposed sack:	775 sack

Fluid 3: Tail Slurry

NeoCem TM	Fluid Weight:	14.5 lbm/gal
0.3 % HR-7	Slurry Yield:	1.097 ft3/sack
4.63 Gal/sk FRESH WATER	Total Mixing Fluid:	4.63 Gal/sack
	Calculated Volume:	**89.9 bbl**
	Proposed Volume:	**89.9 bbl**
	Top Of Fluid:	5,000 ft
	Calculated Fill:	2,000 ft
	Calculated sack:	459.97 sack
	Proposed sack:	460 sack

Fluid 4: Fresh Water

Fresh Water	Fluid Density:	8.33 lbm/gal
	Volume:	**260 bbl**

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5.4 Volume Estimate Table 7" DV Production Casing

Calculations are used for volume estimation. Well conditions will dictate final cement job design.

Stage 1

Fluid #	Fluid Type	Fluid Name	Surface Density lbm/gal	Estimated Avg Rate	Downhole Volume
1	SPACER	12.0 lb/gal Tuned Spacer III	12		50 bbl
2	CEMENT	Lead Cement	12.5		71.2 bbl
3	CEMENT	Tail Cement	14.5		186.9 bbl
4	MUD	Water Based Mud	11		454.1 bbl

Stage 2

Fluid #	Fluid Type	Fluid Name	Surface Density lbm/gal	Estimated Avg Rate	Downhole Volume
1	SPACER	12.0 lb/gal Tuned Spacer III	12		50 bbl
2	CEMENT	Lead Cement	12.5		225.3 bbl
3	CEMENT	Tail Cement	14.5		89.9 bbl
4	MUD	Fresh Water	8.33		260 bbl

NOTE: These slurries and spacers will require lab testing. The additives and concentrations are estimates based on field experience in the area and may need to be modified prior to the job. The proposed spacer is designed to be generally compatible with water base mud systems. Compatibility testing with field mud samples used may indicate changes in the additive package and the related costs.

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5.5 Cost Estimate

Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
392189	**CMT MULTIPLE STAGES BOM** ***392189***	1.00	JOB	0.00	0.00
Cementing Services & Equipment					
1	ZI-MILEAGE FROM NEAREST HES BASE,/UNIT Number of Units	480.00 1	MI	USD 9.79/ 1 MI	4,699.20
2	MILEAGE FOR CEMENTING CREW Number of Units	480.00 1	MI	USD 5.76/ 1 MI	2,764.80
16093	MSC PUMP CHARGE (1ST STAGE), ZI FEET/METERS (FT/M) DEPTH	1.00 FT 12305	EA	USD 27,887.00/ 1 EA	8,784.40
16	MULTIPLE STAGE CEMENTING Number of Units	1.00 1	STG	USD 5,055.00/ 1 STG	2,527.50
141	RCM II W/ADC,/JOB,ZI ENTER FEET\METER\JOB\DAY NUMBER OF JOBS NUMBER OF UNITS	1.00 JOB 1 1	JOB	USD 1,990.00/ 1 JOB	1,990.00
132	PORT. DAS W/CEMWIN;ACQUIRE W/HES, ZI NUMBER OF DAYS	1.00 1	JOB	USD 1,649.00/ 1 JOB	1,649.00
119534	SUCTION HOSE, 4"/FT W/HES,PER JOB ZI NUMBER OF JOBS	100.00 1	FT	USD 4.40/ 1 FT	440.00
14089	PUP TRAILER,NON-ACID MATLS,0-8 HRS,ZI HR/DAY/WEEK/MTH/YEAR/JOB/RUN HOURS (MIN8)	1.00 H 8	EA	USD 822.00/ 1 EA	822.00
74038	ZI PLUG CONTAINER RENTAL-1ST DAY HR/DAY/WEEK/MTH/YEAR/JOB/RUN DAYS OR FRACTION (MIN1)	1.00 DAY 1	EA	USD 1,322.00/ 1 EA	1,322.00
90	ZI QUICK LATCH ATTACHMENT INCHES/MILLIMETERS (IN/MM) SIZE IN INCHES/MILLIMETER	1.00 IN 10.75	JOB	USD 616.00/ 1 JOB	616.00
11941	FIELD STORAGE BIN DEL & RETURN, ZI Number of Units	480.00 2	MI	USD 9.79/ 1 MI	2,960.50
16115	FIELD STORAGE BIN ON SITE >8 HRS,DAY,ZI DAYS OR PARTIAL DAY(WHOLE NO.)	1.00 2	EA	USD 1,344.00/ 1 EA	2,688.00
	SubTotal				**31,263.40**
Cement Materials					
483826	SBM, CMT, Tuned Spacer III	50.00	BBL	USD 284.00/ 1 BBL	4,473.00
101007444	CHEM, D-AIR 3000L, 5 GAL PAIL *D-AIR 3000L*	5.00	GAL	USD 140.55/ 1 GAL	221.37
100001615	CHEM, FE-2 *FE-2*	25.00	LB	USD 5.56/ 1 LB	43.78
1257440	CHEM, BARITE, BULK *BARITE*	8,770.00	LB	USD 0.31/ 1 LB	856.39
1012301	SBM CEM NEOCEM™ LEAD	70.00	BBL	USD 50.00/ 1 BBL	3,500.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	98.00	LB	USD 5.88/ 1 LB	181.52

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Mtrl Nbr	Description	Qty	UOM	Unit Price	Net Amount
984579	SBM CEM NEOCEM™ TAIL	186.00	BBL	USD 70.00/ 1 BBL	13,020.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	202.00	LB	USD 5.88/ 1 LB	374.14
100005055	CHEM, HR-7 Cement Retarder *HR-7*	310.00	LB	USD 5.88/ 1 LB	574.18
483826	SBM, CMT, Tuned Spacer III	50.00	BBL	USD 284.00/ 1 BBL	4,473.00
100001615	CHEM, FE-2 *FE-2*	25.00	LB	USD 5.56/ 1 LB	43.78
101007444	CHEM, D-AIR 3000L, 5 GAL PAIL *D-AIR 3000L*	5.00	GAL	USD 140.55/ 1 GAL	221.37
1012301	SBM CEM NEOCEM™ LEAD	225.00	BBL	USD 40.00/ 1 BBL	9,000.00
100005055	CHEM, HR-7 Cement Retarder *HR-7*	111.00	LB	USD 5.88/ 1 LB	205.59
984579	SBM CEM NEOCEM™ TAIL	90.00	BBL	USD 55.00/ 1 BBL	4,950.00
76400	MILEAGE,CMT MTLS DEL/RET MIN NUMBER OF TONS	240.00 108.512	MI	USD 3.35/ 1 MI	27,481.75
3965	HANDLE&DUMP SVC CHRG, CMT&ADDITIVES,ZI Unit of Measurement NUMBER OF EACH	2,675.00 EA 1	CF	USD 5.49/ 1 CF	4,626.01
	SubTotal				**74,245.88**
Non-Discounted Items					
7	ENVIRONMENTAL CHARGE,/JOB,ZI	3.00	JOB	USD 134.00/ 1 JOB	402.00
11881	OVERWEIGHT PERMIT FEE-CEMENTING	12.00	EA	USD 60.00/ 1 EA	720.00
1257440	CHEM, BARITE, BULK *BARITE*	8,770.00	LB	USD 0.31/ 1 LB	856.39
17	MSC ON SITE,ADD HR,ZI Number of Units	1.00 1	H	USD 1,139.00/ 1 H	1,139.00
	Total Gross Amount				**233,752.18**
	Total Item Discounts				**125,125.51**
	Total Net Amount	**USD**			**108,626.67**

Primary Plant: Bossier City, LA, USA
Secondary Plant: Bossier City, LA, USA
Price Book Ref: 29 - SOUTHEAST
Price Date: 10/01/23

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6 Proposal Cost Summary

Job Name	Cost
16" Surface Casing	80,380.26
10 3/4" DV Intermediate Casing	109,973.05
7" DV Production Casing	108,626.67
Total Cost USD	298,979.98

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7 Conditions

The cost in this analysis is good for the materials and/or services outlined within and shall be valid for 30 days from the date of this proposal. In order to meet your needs under this proposal with a high quality of service and responsive timing, Halliburton will be allocating limited resources and committing valuable equipment and materials to your area of operations. Accordingly, the discounts reflected in this proposal are available only for materials and services awarded on a first-call basis. Alternate pricing may apply in the event that Halliburton is awarded work on any basis other than as a first-call provider.

The unit prices stated in the proposal are based on our current published prices. The projected equipment, personnel, and material needs are only estimates based on information about the work presently available to us. At the time the work is actually performed, conditions then existing may require an increase or decrease in the equipment, personnel, and/or material needs. Charges will be based upon unit prices in effect at the time the work is performed and the amount of equipment, personnel, and/or material actually utilized in the work. Taxes, if any, are not included. Applicable taxes, if any, will be added to the actual invoice.

It is understood and agreed between the parties that with the exception of the subject discounts, all services performed and equipment and materials sold are provided subject to Halliburton's General Terms and Conditions contained in our current price list, (which include LIMITATION OF LIABILITY and WARRANTY provisions), and pursuant to the applicable Halliburton Work Order Contract (whether or not executed by you), unless a Master Service and/or Sales Contract applicable to the services, equipment, or materials supplied exists between your company and Halliburton, in which case the negotiated Master Contract shall govern the relationship between the parties. A copy of the latest version of our General Terms and Conditions is available from your Halliburton representative or at: http://www.halliburton.com/terms for your convenient review, and we would appreciate receiving any questions you may have about them. Should your company be interested in negotiating a Master Contract with Halliburton, our Law Department would be pleased to work with you to finalize a mutually agreeable contract. In this connection, it is also understood and agreed that Customer will continue to execute Halliburton usual field work orders and/or tickets customarily required by Halliburton in connection with the furnishing of said services, equipment, and materials.

Any terms and conditions contained in purchase orders or other documents issued by the customer shall be of no effect except to confirm the type and quantity of services, equipment, and materials to be supplied to the customer.

If customer does not have an approved open account with Halliburton or a mutually executed written contract with Halliburton, which dictates payment terms different than those set forth in this clause, all sums due are payable in cash at the time of performance of services or delivery of equipment, products, or materials. If customer has an approved open account, invoices are payable on the twentieth day after date of invoice.

Customer agrees to pay interest on any unpaid balance from the date payable until paid at the highest lawful contract rate applicable, but never to exceed 18% per annum. In the event Halliburton employs an attorney for collection of any account, customer agrees to pay attorney fees of 20% of the unpaid account, plus all collection and court costs.

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APPENDIX

VI-3 Corrosivity Toward Steel

Republic Services -- Itasca Landfill
Corrosivity Toward Steel

1.0 SCOPE AND APPLICATION

1.1 Corrosion coupon testing is an in-line monitoring technique

2.0 SUMMARY OF METHOD

2.1 Weighed coupons of the same materials as those used in the injection tubing, packer, and long string casing are placed directly in the process stream and those materials must be continuously exposed to the operating pressures and temperatures (measured at the wellhead) and flow rates of the injection operation; and extracted for measurement Quarterly. This monitoring technique provides a direct measurement of metal loss that allows you to calculate the general corrosion rate.

3.0 INTERFERENCES

3.1 Coupon orientation must be consistent in order to make different data sets comparable. An orientation parallel to the process flow is preferable since this more nearly reflects the true condition experienced by the vessel wall.

4.0 APPARATUS AND MATERIALS

4.1 A weighed coupon of the same material as the injection tubing, packer, and long string casing.

4.2 A fixed (pipe plug) coupon holder 2” NPT constructed in AISI 316L stainless steel.

4.3 Coupons should be measured carefully to permit accurate calculation of the exposed area.

5.0 REAGENTS

5.1 Coupons are placed directly into the process stream

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Shut down, isolation and depressurization is required for sample collection.

6.2 Clean laboratory gloves should be worn when handling coupons to prevent moisture and body oils present on the skin from coming in contact with the unexposed coupon.

6.3 Exposed coupons should be cleaned and weighed as soon as possible after their removal.

7.0 PROCEDURE

7.1 Remove exposed coupon from injection piping.

7.2 In order to determine accurately the amount of material lost to corrosion, the coupons have to be cleaned after extraction and prior to weighing. The cleaning procedure should remove all products of corrosion while removing a minimum of sound metal. Mechanical cleaning includes scrubbing, scraping, brushing, and ultrasonic procedures. Scrubbing with a bristle brush and mild abrasive is the most popular.

7.3 After corroded specimens have been cleaned and dried, they are reweighed. The weight loss is employed as the principal measure of corrosion. In order to determine the corrosion rate for the purpose of this regulation, the following formula is used:

Corrosion Rate (mmpy) = (87500 x weight loss)/(alloy density x area x time) (Reference 1),
then,

$$\text{Corrosion Rate (mmpy)} = \frac{87500 \times W}{AD \times A \times T}$$

W= weight loss (g)
AD= alloy density (g/cm³)
A= exposed area
T= exposure time (hr)

8.0 QUALITY CONTROL

8.1 All quality control data should be filed and available for auditing.

9.0 METHOD PERFORMANCE

9.1 No data provided.

10.0 REFERENCES

National Association of Corrosion Engineers, “Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Oilfield Operations” NACE Standard RP0775-2005, NACE International, 1440 South Creek Drive, Houston, TX 77084

Republic Services
Itasca Landfill
SW-#####

Date: _____

Lab #: _____

RE: Injection Fluid
Quarterly Composite
Corrosivity Toward Steel

_____ Quarter, _____

IW-1
Strip Coupon # _____
EXPOSED SURFACE AREA (cm^2)

Face: _____

Back: _____

Sides: _____

Top & Bottom: _____

TOTAL _____ cm^2

MASS (g)

Initial _____

Final _____

Loss _____ g

MASS (g)

Initial _____

Final _____

Loss _____ g

INCUBATION TIME (hr)

Start Date: _____ Stop Date: _____ Incubation Time

Start Time: _____ Stop Time: _____ Net Hours: _____

Corrosion Calculation: $mmpy = \frac{(87500)(w)}{(AD)(A)(T)}$

W= weight loss (g)
AD= alloy density(g/cm^3)
A= exposed area
T= exposure time (hr)

IW-1 Strip Coupon #_____ (87500)(_____) / (_____)(_____)(_____) = _____mmpy

ATTEST: _____

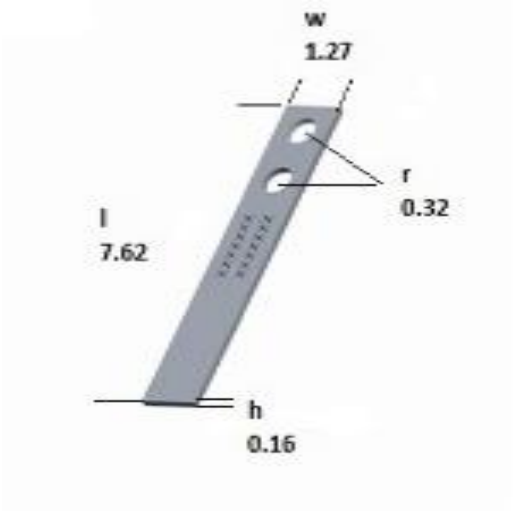
Date: _____

Lab #: _____

Republic Services Itasca
Strip Coupon

_____ QTR, 2_____

Coupon # _____



Dimensions (cm)

l	7.62	cm
w	1.27	cm
h	0.16	cm
r	0.32	cm

Surface Area (cm^2)

Face:	$lw - 2\pi r^2$	=	(_____)(_____) - 2(_____)(_____)^2	= _____cm^2
Back:	$lw - 2\pi r^2$	=	(_____)(_____) - 2(_____)(_____)^2	= _____cm^2
Sides:	$2lh$	=	2(_____)(_____)	= _____cm^2
Top & Bottom:	$2wh$	=	2(_____)(_____)	= _____cm^2

TOTAL _____

ATTEST: _____

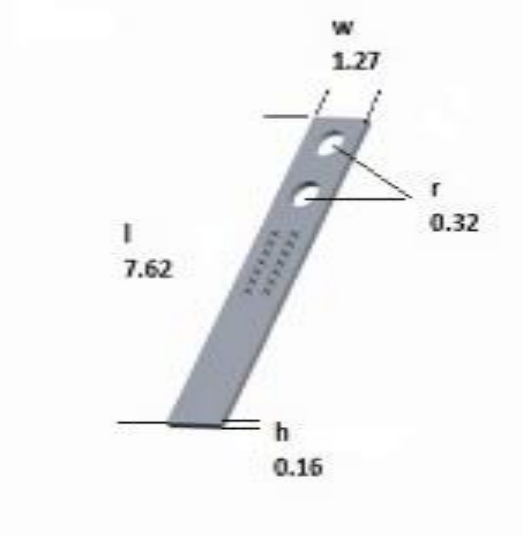
Date: _____

Lab #: _____

Republic Services Itasca
Strip Coupon

_____ QTR, 2_____

Coupon # _____



Dimensions (cm)

l	7.62	cm
w	1.27	cm
h	0.16	cm
r	0.32	cm

Surface Area (cm^2)

Face:	$lw - 2\pi r^2$	=	(_____)(_____) - 2(_____)(_____)^2	= _____cm^2
Back:	$lw - 2\pi r^2$	=	(_____)(_____) - 2(_____)(_____)^2	= _____cm^2
Sides:	$2lh$	=	2(_____)(_____)	= _____cm^2
Top & Bottom:	$2wh$	=	2(_____)(_____)	= _____cm^2

TOTAL _____

ATTEST: _____

APPENDIX

VI-4 Closure Plan

APPENDIX VI-4
CLOSURE PLAN

Final Testing Program

After ceasing injection in the well prior to commencing physical closure procedures of the injection well, a pressure falloff test will be conducted in order to determine if the transient pressure data have conformed with predicted values within the injection interval. The brine injected for the falloff test will be nonhazardous and will also act as a buffer between the injectate and the well. Appropriate mechanical integrity testing shall also be conducted to ensure the integrity of the long casing string and cement that will remain in the ground after closure. Notify the TCEQ of mechanical integrity and pressure falloff testing procedures of the long casing string and cement that will remain.

Mechanical Integrity Testing

An annular pressure test and radioactive tracer survey will be conducted prior to removing the injection tubing and packer. Subsequent to tubing and packer removal, a casing inspection and a cement bond/variable density log will be conducted from total depth to the surface.

Pressure Falloff Testing

Rig up the wireline unit with pressure control equipment. Run into the hole with a surface recording bottom-hole pressure transducer with temperature capabilities and position the transducer at the top of the injection interval. Allow the transducer to stabilize prior to injecting brine.

Commence injecting 2,000 barrels of brine at a constant rate. The brine will be compatible with the injection zone reservoir fluid as determined by compatibility testing. Record the pressure buildup. Cease pumping and record the pressure falloff. Measure the pressure falloff for a minimum of 24 hours after shut in. Monitor the pressure derivative curve to confirm the test has investigated beyond the wellbore storage effect.

Notification of Executive Director

According to 30 TAC 331.46(e), Republic Services will notify the Executive Director at least 60 days before commencing plugging and abandonment procedures on any waste disposal well.

Plug and Abandonment Procedures

The balance plug method will be employed to plug and abandon this well. This technique involves displacing the cement through a work string which has been run into the casing. The cement slurry is pumped down the work string and up the annulus to a calculated height which would balance the cement inside and outside the work string. The work string is then slowly pulled out of the cement leaving a solid, uniform plug.

Heavy drilling mud is placed between the cement plugs. This mud establishes a hydrostatic gradient that will exceed the static bottom-hole pressure at the time of plugging and any anticipated pressures which would result from future injection activity in these particular formations.

Finally, after all cement plugs are set, the well casings will be cut off 3 feet below grade and capped by welding a ½ inch steel plate to the outermost casing string.

The plugging and abandonment procedures for a typical well are described as follows:

1. Prepare the well and location for plugging. Remove the wellhouse (if present), well monitoring equipment, and wellhead injection piping.
2. Notify the TCEQ of the MIT schedule. Conduct an annulus pressure test and a radioactive tracer survey to satisfy TCEQ mechanical integrity requirements.
3. Move in and rig up the frac tanks and pump for the pressure falloff test. Fill frac tanks with 2,000 barrels of brine.
4. Rig up the wireline unit with pressure control equipment. Run into the hole with a surface recording bottom-hole pressure transducer with temperature capabilities and position the transducer at the top of the injection interval. Allow the transducer to stabilize prior to injecting brine.
5. Commence injecting 2,000 barrels of brine at a constant rate. The brine will be compatible with the injection zone reservoir fluid, as determined by compatible testing. Record the pressure buildup. Cease pumping and record the pressure falloff. Measure the pressure falloff for a minimum of 24 hours after shut in. Monitor the pressure derivative curve to confirm the test has investigated beyond the wellbore storage effect.
6. Rig down the wireline unit.
7. Move in and rig up the well service unit with BOP equipment and a 2 7/8 inch work string.
8. Remove the wellhead and install the BOP equipment and stripper head.
9. Unseat the packer and displace the annular fluid by flushing annulus with 200 bbls of brine.
10. Trip out of the hole laying down the 4 1/2 inch injection tubing and packer.
11. Rig up the wireline unit and run a casing inspection log and a cement bond/variable density log from total depth to the surface. Pick up and run a cement retainer to 9,000 feet or 50 feet above top possible perforation, whichever is shallower. Rig down the wireline unit.
12. Trip in hole and sting into cement retainer at 9,000 feet.
13. Rig up cement service equipment. Cement shall be Class "C" (or comparable), weighing 15.6 pounds/gallon. Pressure test the surface lines as required.
14. Pump/squeeze 185 bbls of 15.6 ppg Class “C” cement (Plug #1), equivalent to 1.5X the casing volume between 9,000 feet and total depth of 12,305 feet, in order to plug off the perforations.
15. Pull out of the retainer, and spot a 1,000-ft balanced plug of 177 sacks (1.18 ft^3/sk) of 15.6 ppg Class “C” cement (Plug #2 – 37 bbls) onto the retainer with a top at 8,000 feet. Pull up a stand

above estimated TOC and reverse out any excess cement. Pull up a few stands and allow time (8 hour minimum) for the cement plug to cure. Tag the top of cement and pressure test the casing to the TCEQ required test pressure for 30 minutes and record the test.

16. Using necessary spacer fluids and pre-flushes, spot balanced plug of 177 sacks (1.18 ft^3/sk) of 15.6 ppg Class "C" (or comparable) cement slurry (Plug #3 – 37 bbls) to develop a cumulative 1,000-foot column (minimum) from 8,000 feet to 7,000 feet. Pull the tubing up a stand above the estimated TOC and reverse out excess cement. Catch a sample of cement to check curing time and compressive strength. Allow the cement to set (8-hour minimum) before tagging top of plug to confirm proper setup and location. Pressure test the plug to the pressure required by the TCEQ for 30 minutes and record the test. If cement is set adequately, proceed to Step 17. Otherwise, spot additional cement on top of the previous plug, as before, to achieve a cumulative 1,000-foot cement plug. Allow cement to set for a longer period, if necessary.
17. Repeat step 16 to place 1,000-foot cement plugs from 7,000 feet to Surface (Plugs #4 -10). Pull the tubing out of the hole. (The base of the USDW at IW-1 is at approximately 2030 feet.)
18. Cut casing strings ±3 feet below ground level.
19. Weld a ½ inch steel plate across the 7 inch casing. Inscribe on plate, in a permanent manner, the following information: (1) operator name, (2) closure date, and (3) UIC permit number.
20. Release all equipment and clean up the location.
21. Submit closure data to the TCEQ.

Once closure operations are complete and the well is officially plugged and abandoned, a closure report certifying that the well or wells were closed in accordance with applicable requirements, will be submitted to the proper agencies within 30 days of plugging the well. The report will include any newly constructed or discovered wells or information, including proposed well data, within the area of review. When plugging and abandonment is complete, Republic Services will submit certification to the Executive Director (by Republic Services and by a licensed, professional engineer with current registration pursuant to the Texas Engineering Practice Act, who is knowledgeable and experienced in practical drilling engineering and who is familiar with the special conditions and requirements of injection well construction) that the injection well has been closed in accordance with 30 TAC §§ 331.46.

APPENDIX

VI-5 P&A Bond

PERFORMANCE BOND

Date bond executed: October 16, 2023.

Effective date: October 31, 2023.

Principal: Republic Industrial and Energy Solutions, LLC, 2559 FM 66, Itasca, TX 76055.

Type of organization: Limited Liability Company.

State of incorporation: Delaware.

Surety(ies): Evergreen National Indemnity Company, 6150 Oak Tree Blvd., Ste 440, Independence, OH 44131.

Permit number, name, physical and mailing addresses, and closure, post closure, or corrective action amounts(s) for each facility guaranteed by this bond:

Permit#: SWR 86925 / Itasca Deep Well
Name: Republic Industrial and Energy Solution, LLC
Physical Address: 2559 FM 66, Itasca, TX 76055
Mailing Address: 10613 W. Sam Houston Parkway N., Ste 300 Houston, TX 77064
Closure Amount: $526,478.00

Total penal sum of bond: $ 526,478.00.

Surety's bond number: 880377.

Know All Persons By These Presents, That We, the Principal and Surety(ies) hereto are firmly bound to the Texas Commission on Environmental Quality, hereinafter called TCEQ, in the above penal sum for the payment of which we bind ourselves, our heirs, executors, administrators, successors, and assigns jointly and severally; provided that, where the Surety(ies) are corporations acting as co-sureties, we, the Sureties, bind ourselves in such sum "jointly and severally" only for the purpose of allowing a joint action or actions against any or all of us, and for all other purposes each Surety binds itself, jointly and severally with the Principal, for the payment of such sum only as is set forth opposite the name of such Surety, but if no limit of liability is indicated, the limit of liability shall be the full amount of the penal sum.

Whereas said Principal is required, under the appropriate program area, to comply with permit requirements in order to own or operate each facility identified above, and

Whereas said Principal is required to provide financial assurance for closure, post closure, or corrective action as a condition of the permit or other applicable requirements, and

Whereas said Principal shall establish a standby trust fund as is required when a surety bond is used to provide such financial assurance;

Now, therefore, the conditions of this obligation are such that if the Principal shall faithfully perform closure, post closure, or corrective action, whenever required to do so, of each facility for which this bond guarantees closure or post closure in accordance with the closure plan or post closure plan and other applicable requirements of the permit, or perform corrective action in accordance with the

permit or other applicable requirements as may be amended, pursuant to all applicable laws, statutes, rules and regulations, as such laws, statutes, rules, and regulations may be amended,

Or, if the Principal shall provide alternate financial assurance, as specified in 30 Texas Administrative Code, Chapter 37 (relating to Financial Assurance) and obtain the TCEQ executive director's written approval of such assurance, within 90 days after the date of notice of cancellation is received by both the Principal and the TCEQ executive director from the Surety(ies), then this obligation shall be null and void, otherwise it is to remain in full force and effect.

The Surety(ies) shall become liable on this bond obligation only when the Principal has failed to fulfill the conditions described above.

Upon notification by the TCEQ executive director that the Principal has been found in violation of the closure, post closure, or corrective action requirements for a facility for which this bond guarantees performance of closure, post closure, or corrective action, the Surety(ies) shall either perform closure, post closure, or corrective action in accordance with the closure plan or post closure plan and other applicable requirements of the permit, or perform corrective action in accordance with the permit or other applicable requirements, or place the amount guaranteed for the facility in the standby trust fund as directed by the TCEQ executive director.

Upon notification by the TCEQ executive director that the Principal has failed to provide alternate financial assurance, as specified in 30 Texas Administrative Code, Chapter 37, and obtain written approval of such assurance from the TCEQ executive director during the 90 days following receipt by both the Principal and the TCEQ executive director of a notice of cancellation of the bond, the Surety(ies) shall place funds in the amount guaranteed for the facility(ies) into the standby trust fund.

The surety(ies) hereby waive(s) notification of amendments to closure plans or post closure plans and other applicable requirements of the permit, or permits requiring corrective action or other applicable requirements for corrective action, applicable laws, statutes, rules, and regulations and agrees that no such amendment shall in any way alleviate its (their) obligation on this bond.

The liability of the Surety(ies) shall not be discharged by any payment or succession of payments hereunder, unless and until such payment or payments shall amount in the aggregate to the penal sum of the bond, but in no event shall the obligation of the Surety(ies) hereunder exceed the amount of said penal sum.

The Surety(ies) may cancel the bond by sending notice of cancellation by certified mail to the owner and operator and to the TCEQ executive director provided, however, that cancellation shall not occur during the 120 days beginning on the date of receipt of the notice of cancellation by both the Principal and the TCEQ executive director, as evidenced by the return receipts.

The principal may terminate this bond by sending written notice to the Surety(ies), provided, however, that no such notice shall become effective until the Surety(ies) receive(s) written authorization for termination of the bond by the TCEQ executive director.

Principal and Surety(ies) hereby agree to adjust the penal sum of the bond yearly so that it guarantees a new closure, post closure, or corrective action amount, provided that the penal sum does

not increase by more than 20 percent in any one year, and no decrease in the penal sum takes place without the written permission of the TCEQ executive director.

In Witness Whereof, The Principal and Surety(ies) have executed this Performance Bond and have affixed their seals on the date set forth above.

The persons whose signatures appear below hereby certify that they are authorized to execute this surety bond on behalf of the Principal and Surety(ies) and that the wording on this surety bond is identical to the wording specified in 30 Texas Administrative Code § 37.321 as such regulation was constituted on the date this bond was executed.

Principal

(Signature(s))_____

(Name(s)) Amber Engel

(Title(s)) Attorney-in-Fact

(Corporate seal)

(Corporate Surety(ies))

(Name and address) Evergreen National Indemnity Company 6150 Oak Tree Blvd., Ste 440 Independence, OH 44131

State of Incorporation: Ohio

Liability limit: $ 526,478.00

(Signature(s))_____

(Name(s) and title(s)) Debbie Lindstrom, Attorney-in-Fact

(Corporate seal)

Bond premium: $ 4,212.00

REPUBLIC SERVICES

POWER OF ATTORNEY

REPUBLIC SERVICES, INC., a Delaware corporation having its principal place of business at 18500 N. Allied Way, Phoenix, Arizona 85054, hereby makes, constitutes and appoints KIBBLE & PRENTICE HOLDING COMPANY dba USI INSURANCE SERVICES NORTHWEST, acting through and by any one of Debbie Lindstrom, Kathleen M. Mitchell, Scott C. Alderman, Amber Engel, Jamie Armfield, Holly E. Ulfers, or Roxana Palacios, its true and lawful attorney to sign and seal any and all surety bonds, bid bonds, performance bonds and payment bonds at or below the monetary threshold of Five Million Dollars ($5,000,000.00) on behalf of REPUBLIC SERVICES, INC. and its subsidiaries, relating to the provision of solid waste collection, transportation, transfer, recycling, disposal and/or energy services by REPUBLIC SERVICES, INC. and its subsidiaries and affix its corporate seal to and deliver for and on behalf as surety thereon or otherwise, bonds of any of the following classes, to wit:

1. Surety bonds, bid bonds, performance bonds and payment bonds to the United States of America or agency thereof, including those required or permitted under the laws or regulations relating to Customs or Internal Revenue; license and permit bonds or other indemnity bonds under the laws, ordinances or regulations of any state, city, town, village, board, other body organization, public or private; bonds to transportation companies; lost instrument bonds; lease bonds; worker's compensation bonds; miscellaneous surety bonds; and bonds on behalf of notaries public, sheriffs, deputy sheriffs and similar public officials.

2. Surety bonds, bid bonds, performance bonds and payment bonds on behalf of REPUBLIC SERVICES, INC. and its subsidiaries in connection with bids, proposals or contracts.

REPUBLIC SERVICES, INC. hereby agrees to ratify and confirm whatsoever KIBBLE & PRENTICE HOLDING COMPANY dba USI INSURANCE SERVICES NORTHWEST shall lawfully do pursuant to this power of attorney, and until notice or revocation has been given by REPUBLIC SERVICES, INC., the acts of said attorney shall be binding on the undersigned.

IN WITNESS WHEREOF, this Power of Attorney has been signed this 24th day of May, 2023 on behalf of REPUBLIC SERVICES, INC. by its Assistant Secretary, Adrienne W. Wilhoit.

REPUBLIC SERVICES, INC.,
a Delaware corporation

Adrienne W. Wilhoit

STATE OF ARIZONA

COUNTY OF MARICOPA

Subscribed and sworn to before me this 24th day of May, 2023 by Kiara Gonzalez, Notary Public.

KIARA GONZALEZ
Notary Public - Arizona
Maricopa County
Commission # 598522
My Comm. Expires Feb 2, 2025

Notary Public

CERTIFICATE

I, the undersigned, John B. Nickerson, Assistant Secretary of Republic Services, Inc., a Delaware corporation, do hereby certify that the foregoing Power of Attorney is true, correct, remains in full force and effect, and has not been revoked.

IN WITNESS WHEREOF, this Certification has been signed this 16th day of October, 2023 on behalf of REPUBLIC SERVICES, INC. by its Assistant Secretary, John B. Nickerson.

John B. Nickerson

EVERGREEN NATIONAL INDEMNITY COMPANY

Independence, Ohio

POWER OF ATTORNEY

Bond No. 880377

KNOW ALL MEN BY THESE PRESENTS: That the Evergreen National Indemnity Company, a corporation in the State of Ohio does hereby nominate, constitute and appoint:

Debbie Lindstrom

its true and lawful Attorney(s)-In-Fact to make, execute, attest, seal and deliver for and on its behalf, as Surety, and as its act and deed, where required, any and all bonds, undertakings, recognizances and written obligations in the nature thereof, PROVIDED, however, that the obligation of the Company under this Power of Attorney shall not exceed TWENTY-FIVE MILLION AND 00/100 DOLLARS ($25,000,000.00)

This Power of Attorney is granted and is signed by facsimile pursuant to the following Resolution adopted by its Board of Directors on the 23rd day of July, 2004:

> "RESOLVED, That any two officers of the Company have the authority to make, execute and deliver a Power of Attorney constituting as Attorney(s)-in-fact such persons, firms, or corporations as may be selected from time to time.
> FURTHER RESOLVED, that the signatures of such officers and the Seal of the Company may be affixed to any such Power of Attorney or any certificate relating thereto by facsimile; and any such Power of Attorney or certificate bearing such facsimile signatures or facsimile seal shall be valid and binding upon the Company; and any such powers so executed and certified by facsimile signatures and facsimile seal shall be valid and binding upon the Company in the future with respect to any bond or undertaking to which it is attached."

IN WITNESS WHEREOF, the Evergreen National Indemnity Company has caused its corporate seal to be affixed hereunto, and these presents to be signed by its duly authorized officers this 1st day of April, 2022.

EVERGREEN NATIONAL INDEMNITY COMPANY

EVERGREEN NATIONAL INDEMNITY COMPANY CORPORATE SEAL 1939 OHIO

By: _____
Matthew T. Tucker, President

By: _____
David A. Canzone, CFO

Notary Public)
State of Ohio) SS:

On this 1st day of April, 2022, before the subscriber, a Notary for the State of Ohio, duly commissioned and qualified, personally came Matthew T. Tucker and David A. Canzone of the Evergreen National Indemnity Company, to me personally known to be the individuals and officers described herein, and who executed the preceding instrument and acknowledged the execution of the same and being by me duly sworn, deposed and said that they are the officers of said Company aforesaid, and that the seal affixed to the preceding instrument is the Corporate Seal of said Company, and the said Corporate Seal and signatures as officers were duly affixed and subscribed to the said instrument by the authority and direction of said Corporation, and that the resolution of said Company, referred to in the preceding instrument, is now in force.

IN TESTIMONY WHEREOF, I have hereunto set my hand and affixed my official seal at Cleveland, Ohio, the day and year above written.

Julie K Bowers
Notary Public
in and For the State of Ohio
My Commission Expires
August 13, 2024

_____
Julie K. Bowers, Notary Public
My Commission Expires August 13, 2024

State of Ohio) SS:

I, the undersigned, Secretary of the Evergreen National Indemnity Company, a stock corporation of the State of Ohio, DO HEREBY CERTIFY that the foregoing Power of Attorney remains in full force and has not been revoked; and furthermore that the Resolution of the Board of Directors, set forth herein above, is now in force.

Signed and sealed in Independence, Ohio, this 16th day of October, 2023.

EVERGREEN NATIONAL INDEMNITY COMPANY CORPORATE SEAL 1939 OHIO

_____
Wan C. Collier, Secretary

APPENDIX

VI-6 IW-1 Closure Cost

APPENDIX VI-6
IW-1 CLOSURE COST

TOTAL COST ESTIMATE		$ 526,478
MANAGEMENT COST		**$ 25,580**
Labor - Office		13,660
Labor - Field		9,600
Expenses		2,320
SERVICES & RENTALS		**$ 411,851**
Brine & Frac Tanks		17,861
Rental Tools, Fishing Tools & Services		12,178
Cement, Cement Services, Hardware		203,037
Logging, Perforating & Wireline Services		37,888
Workover Rig		58,455
Pump Truck		8,660
Casing Crews & Laydown Machine		31,934
Welding		3,789
Transportation		10,825
Hauling, Vacuum Trucks & Disposal		11,908
Location Rentals		7,523
Health, Safety & Environmental		7,794
Hazardous Waste Well Surcharge		-
PROJECT MANAGEMENT FEES	**Rate**	**$ 41,185**
Services And Rentals	10%	41,185
PM RESERVE & CONTINGENCIES	**Rate**	**$ 47,862**
Risk Contingency	10%	47,862

Well Data

Hazardous Waste Well?	No	
Avg Well Inside Diameter (7" 29# CSG)	6.184	in
Top of Confining Interval	8,520	ft
Top of Injection Interval	8,769	ft
Total Depth	12,305	ft
Calculated Mud Volume	457	bbl
Calculated Cement Volume	2,567	ft^3

Assumptions:

Well is assumed to be an orphan well.		
Plugging Method (*4 Plugs or Wellbore-Filled*)	Wellbore-Filled	
Total Brine Used (*1200 PFO, 300 RAT, [illegible]*)	2000	bbl

I, Raymond J. Steppe, III, P. E., certify that the proposed engineering design contained on this page is technically sound.

STATE OF TEXAS
RAYMOND J. STEPPE, III
143783
LICENSED
PROFESSIONAL ENGINEER

Raymond J. Steppe, III Dec 2023

Texas Registered Professional Engineer No. 143783 Date
WSP USA INC.
Texas Engineering Firm# 2263

SECTION VII

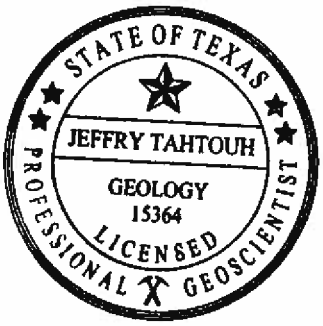
RESERVOIR MECHANICS REPORT

GEOSCIENTIST'S SEAL

I, Jeffry Tahtouh, P.G., the undersigned, state: I am employed by WSP USA, and I am authorized to prepare this document. This document was prepared under my supervision and direction. The information in this document was prepared in accordance with generally accepted geosciences principles and practices.

This certification and seal apply to the following documents:

Pages VII-1 through VII-8
Tables VII-1 through VII-2
Figures VII-1 through VII-9



Name: Jeffry Tahtouh, P.G.
Title: Senior Geologist
WSP USA Inc.
Texas Geoscience Firm 50561

Signature Jeffry Tahtouh Date Signed 12/27/2023
Licensed Professional Geologist No. 15364

VII. RESERVOIR MECHANICS

VII.A.1 INJECTION ZONE STRATIGRAPHY AND LITHOLOGY

The Injection Zone for the proposed injection well is defined as the entire Ellenburger Formation. The top of the Injection Zone is estimated to be found from approximately 8,520 ft BGL to 12,320 ft BGL at the NTI Facility. The Ellenburger Formation is the oldest, deepest, and thickest karst dolomite/limestone formation, found throughout the entire FWB (Appendix V-1 - Hornbach et al., 2016). The thickness of the Ellenburger Formation Injection Zone at the proposed well site is approximately 3,800 ft (Figure V-27).

VII.A.2 INJECTION INTERVAL PHYSICAL CHARACTERISTICS

Physical characteristics of the Injection Interval, including reservoir stratigraphy, lithology, porosity, permeability, thickness and temperature are reviewed in the following sections.

(a) STRATIGRAPHY

The sequence of formations that will be penetrated at the site, in descending order are, the Cretaceous sediments; Pennsylvanian Strawn Group, Atoka Group, upper Smithwick Shale, Big Saline Shale, lower Smithwick Shale; Mississippian Marble Falls Formation and Barnett Shale; Ordovician Viola-Simpson Group, and Ellenburger Formation. These formations have been described in Section V.

(b) LITHOLOGY AND MINERALOGY

The Ellenburger Formation is a complex carbonate system composed of interbedded dolomite, dolomitic limestone, and limestone that contains variable porosity and permeability due to the dominant diagenetic processes, such as dolomitization, karstification, and tectonic fracturing that have produced large cave systems, dolines, karst towers, solution-collapsed zones, and tectonic fractures within the stratigraphic unit.

(c) POROSITY AND PERMEABILITY

Permeability in the Ellenburger Formation is mostly low due to the diagenetic alterations. The Ellenburger Formation is often considered a reservoir rock, having an average porosity and permeability from 5 to 14 percent, and 0.01 to 5,517 mD, respectively (Merrill et al., 2015). The Ellenburger Formation porosity typically ranges between 2% and 12% and averages 4% (Manger, 1963). Regional studies combined with pressure fall-off tests indicate the formation has moderate permeability (0.1–500 mD) (Appendix V–1 Hornbach et al., 2016). A conservative porosity value of 9% was used in modeling which was based on the Formation Density Log run in a Class II injection well (9 miles southwest of the NTI Facility; API 42-217-30457) where the porosity averaged 11.2% in 196 net feet of dolomitic Ellenburger formation (Figure V-16) and ranged from 6% to 32%. A permeability value of 100 mD was used in the modeling based on the average provided in Hornbach et al.'s 2016 research paper (Appendix V-1).

(d) THICKNESS

Table V-2 lists the thickness and depths of the estimated target Injection Interval (Ellenburger Formation). Based on offset log data from the offset well approximately 9 miles from the Itasca facility (Figure V-16) an interval thickness of 150 ft will be utilized for the model which will keep the modeling conservative.

(e) BOTTOM-HOLE TEMPERATURE

A map of geothermal gradients in the region where the NTI Facility is located is presented in Figure VII-1. Geothermal gradient in the area of the NTI Facility is approximately 0.0175°F/ft. The bottom-hole temperature recorded in the offset well 9 miles to the southwest (API: 42-217-30457) was 251°F at 13,087 feet KB (13,069 feet BGL). Due to many factors, the log header BHT measurements are commonly cooler than the equilibrium formation temperatures. To correct the log header temperature, the Kehle Correction Equation was applied (Appendix VII-1). The correction factor was determined to be 33°F and the in-situ temperature at 13,069 feet BGL was determined to be 284°F (33°F + 251°F).

$$Ccf = -8.819 \times 10^{-12} z^3 - 2.143 \times 10^{-8} z^2 + 4.375 \times 10^{-3} z - 1.018$$

Where,

Ccf = Log Header Temperature Correction Factor, Ccf

z = Depth of Log Header Temperature, feet

The average surface temperature for the area is 62°F, and the average temperature gradient was determined to be 0.0170°F/ft [(284 – 62)/13,069 ft].

The top of the injection zone at the NTI Facility for IW-1 is projected to be 8,520 ft BGL, and the midpoint of the injection zone is estimated at 10,420 feet BGL with the base at an estimated 12,320 feet BGL. The BHT at the top of the injection zone and the midpoint of the injection zone are calculated as follows:

BHT at Top of Injection Zone = 0.0170°F/ft x 8520 + 62 = 207°F

BHT at Midpoint of Injection Zone = 0.0170°F/ft x 10420 + 62 = 239°F

(f) FORMATION AND TOTAL COMPRESSIBILITY

The total effective compressibility for an Injection Zone layer is computed from the following equation (Lee, 1982, Page 132):

$$c_t = c_w + c_r$$

where c_w denotes the compressibility of the formation brine alone and c_r is the compressibility of the pores in the formation matrix. The formation compressibility was determined from a correlation presented by Hall (1953) and is shown in this document as Figure VII-2. This correlation gives c_r directly in terms of porosity. Using a porosity of 9% results in a formation compressibility of 5.16×10^{-6} psi^{-1}. The value for c_w is determined to be 2.76×10^{-6} psi^{-1}, as discussed in Section VII.A.3.

The total effective compressibility resulting from addition of these two values is 7.92 x 10^{-6}psi^{-1} based on a porosity of 9%, depth of 10,420 ft BGL, temperature of 239°F, and a pressure of 4724 psi.

VII.A.3 FORMATION FLUID CHARACTERISTICS

(a) SALINITY

Formation fluid samples, unaffected by the existing injection operations have not been obtained from the Ellenburger Formation. The Ellenburger is the single largest aquifer in Texas, and in deep locations it contains hyper saline water (150,000 mg/l, 5x seawater) (Appendix V-1 - Hornbach et al., 2016). Based on Turner's 1957 research, brine with salinity of 100,000 mg/l is used for the pressure build up calculations.

(b) SPECIFIC GRAVITY

The specific gravity for a brine with a salinity of 100,000 mg/l (Section VII.A.3.a) was determined to be 1.0673 at 68°F from the Sodium Chloride table of concentrative properties (Appendix VII-2, Page D-253, CRC Handbook of Chemistry and Physics, 57th Edition, 1976 – 1977). The specific gravity at the midpoint of the Injection Zone at 10,420 feet BGL with a salinity of 10% and a temperature of 239°F was determined using the correlation curves of the calculated brine density from data for dissolved NaCl in water solutions (Figure VII-3).

$$\rho(T) = a_3 - a_2 \times T$$

where,

$\rho(T)$ = brine density at a specific temperature lb/ft^3

a_3 , a_2 = linear fit coefficients, for a 10% salinity brine they are 73.3 and 0.039 respectively

T = Temperature, ° F

$$\rho(T) = 73.3 - 0.039 \times 239 = 63.98 \text{ lbm/ft}^3$$

The estimated brine density is 63.98 lbm/ft^3, which corresponds to a specific gravity of 1.0267.

(c) VISCOSITY

The midpoint of the Injection Zone at 10,420 feet BGL has an estimated temperature of 239°F (Section VII.A.2.e) and an estimated initial pressure of 4,724 psi (Section VII.A.4). The value of the viscosity for the formation brine (equivalent to 9.29% NaCl) (Section VII.A.3.a and Section VII.A.3.b) at this temperature and pressure was determined using Figure VII-4 (generated from equations provided in Appendix VII-3), in addition to the following equation:

$$\mu = \mu T \times f$$

where,

μ = viscosity at reservoir temperature and pressure, cp

μT = viscosity at reservoir temperature and atmospheric pressure, cp

f = viscosity correction factor due to pressure

The viscosity at atmospheric pressure and bottom-hole temperature corresponds to 0.301 cp and the correction factor is 1.02826. The viscosity used for pressure build up calculation is 0.310 cp.

(d) PH

The pH of the formation fluid is expected to be approximately 7.4 based on other formation fluids that have been recovered from wells drilled into the Ellenburger group in Texas (Appendix VII-4 Saline Water Resources of Texas). The pH at the site will be verified when the well is drilled and the formation is sampled (Section VI.A.9.c.ii).

(e) COMPRESSIBILITY

The value of the brine compressibility c_w, was estimated from the Long and Chierici correlation presented by Earlougher (1977) and shown as Figure VII-5. The temperature and pressure in the Ellenburger Injection Interval (239°F and 4,724 psi) were used in determining c_w for NaCl solutions with concentration of 100,000 ppm NaCl, which corresponds to $2.76 \times 10^{-6} psi^{-1}$.

VII.A.4 INITIAL STATIC RESERVOIR PRESSURE AT THE TOP OF THE INJECTION INTERVAL

The hydrostatic gradient in the Ellenburger varies through the basin from 0.433 psi/ft to the southwest to 0.491 psi/ft in the northeast (Hennings et al., 2019). Observed gradients in injection wells located in the neighboring Johnson County (Appendix VII-5) range from 0.458 to 0.466 psi/ft at 9,300 ft, averaging at 0.462 psi/ft. Using the average specific gravity of the formation fluid between the surface and bottom-hole, an initial static reservoir pressure at the midpoint and the top of the Injection Interval were calculated as follows:

BHP at 10,420 ft BGL (Injection Zone Midpoint) = 4,724 psi = (10420 x [1.0673/2 + 1.0267/2] x 0.433)

BHP at 8,520 feet BGL (Injection Interval Top) = 3,879 psi = (4,724 psi – [10420 – 8520] x 1.0267 x 0.433)

VII.A.5 FRACTURES AND FRACTURE GRADIENT

The maximum surface pressure that can be sustained without fracturing the Injection Interval can be determined by:

MSIP =Pt + Pf – Pr – S.F.

where,

MSIP =maximum surface injection pressure, (psig)

P t = pressure drop due to friction loss in the tubing, psi

P_r = pressure due to the hydrostatic head, psi

P_f = pressure to fracture at top of the perforations, psi

S.F. = Safety Factor, psi

If pressure drop due to friction loss in the tubing is ignored, then:

MSIP = Pf – Pr – S.F.

RIES has requested an injectate specific gravity range of 0.9 to 1.2 and a MSIP that will be dependent on the waste stream specific gravity as outlined in Section VI.C.4. Fracturing is most likely to occur at the shallowest depth in the Injection Interval at which the well is completed. This is because the maximum injection pressure remains the same regardless of depth and hydrostatic head increases linearly with depth. The following calculation details the steps taken to calculate the MSIP. The top of the Injection Interval for IW-1 is considered at 8,520 ft BGL. For this calculation the maximum specific gravity is considered:

p_r = depth x 0.433 psi/ft x specific gravity of injectate

= (8,520)(0.433 psi/ft) (1.2)

= 4,427 psi

The overburden stress gradient in the Ellenburger formation is estimated to be 1.11 psi/ft (Quinones et al., 2018).

A fracture gradient of 0.702 psi/ft has been calculated using the method of Eaton (Appendix VII-6).

FG = [(Pob – P) e] / (1-e) + P

where,

FG = fracture gradient (psi/ft)

Pob = overburden pressure gradient (psi/ft) = 1.11 psi/ft

P = reservoir pressure gradient (psi/ft) = 0.462 psi/ft

e = Poisson's ratio = 0.27 (Chen et al,. 2020)

FG = [(1.11 – 0.462) 0.27] / (1 – 0.27) + 0.462 = 0.702 psi/ft

When 0.702 psi/ft is used, a maximum fracture pressure of 5,981 psi is the result.

Pf = 8,520 ft x 0.702 psi/ft

= 5,981 psi

Then,

MSIP = 5,981 psi – 4,427 psi – 100 psi

= 1,454 psi

This calculation was repeated at iterations of 0.001 specific gravity for the waste stream from a specific gravity of 0.9 to 1.2 and are presented in Table VI-6. The requested MSIP values based on specific gravity are presented in Section VI.C.4.

VII.A.6 OTHER SUBSURFACE DISPOSAL OPERATION WITHIN AREA OF REVIEW

There are no injection wells within a 2.5-mile radius of the NTI Facility.

VII.A.7 PRESSURE BUILDUP CALCULATIONS

The primary objective of pressure modeling is to establish the location of the (COI) for IW-1 after 1, 10 and 30 years of continuous injection. It is desirable to utilize reservoir rock properties and fluid properties which will result in calculated pressures which are conservative, i.e., higher, when compared to actual future reservoir pressures. The formation porosity, reservoir brine viscosity, and total compressibility have been discussed in Sections VII.A.2 and VII.A.3.

To model the pressure buildup, WSP's analytical pressure model, Predict W, which is based on an exponential-integral formulation for pressure behavior in a homogenous reservoir, was utilized. The theory of the Predict W model is presented in Appendix VII-7.

A reservoir with one non-transmissive fault is to be considered in the model. Appendix VII-8 contains the PredictW inputs for the pressure buildup modeling. Table VII-1 shows the pressure increase over 1, 10 and 30 years of continuous injection.

The reservoir pressure rise in the Ellenburger is based on an injection rate not to exceed a total of 102 gpm.

Figure VII-6 depicts the pressure increase build up for a 30 year period.

VII.A.8 CONE OF INFLUENCE CALCULATION

The worst-case Cone of Influence calculation occurs at the shallowest depth of the top of the Injection Interval which is at approximately 8,436 feet BGL (7,800 feet BMSL + 636 feet elevation) at the northwestern edge of the Area of Review, 2.5 miles from IW-1. Assuming a 9.0 pound-per-gallon (ppg) mud column 50 ft below ground level, the hydrostatic pressure of this mud column will be 4,031 psi as calculated below:

P_m = Height of Mud column x Mud Pressure gradient

= (8,436 – 50 ft) x 9.0 ppg x 0.052 (psi/ft/ppg)

= 3925 psi

Considering an initial reservoir pressure 3,841.7 psig (3,879 psi – [8,520 ft – 8,436 ft] x 1.0267 SpGr x 0.433 psi/ft) at the reference depth of 8,436 ft BGL, the COI would be defined by the critical pressure rise of 83.3 psi,

$P_{Critical}$ = P_m – BHP

= (3,925 psi - 3,841.7 psi)

= 83.3 psi

Figures VII-7 through VII-9 depict the COI pressure contours ($\Delta P_{Rise} = \Delta P_{Critical}$) for 1, 10 and 30 years of injection at a constant rate of 102 gpm. The radii from IW-1 for these three contours are 95 feet (1-year), 785 feet (10-years) and 3390 feet (30-years). Since the radius of the 30-year contour is less than 2.5 miles (0.64 miles), the Area of Review remains at a radius of 2.5-miles.

Approximately 1 days after injection into IW-1 is terminated, the pressure rise at the wellbore drops to 81.6 psi which is below the critical pressure of 83.3 psi, and there is no longer a COI associated with the operation of IW-1. One year after injection ceases, the pressure rise at the well falls to 34.9 psi which will be 48.4 psi below the critical pressure.

VII.A.9 IMPACT OF EXISTING FACILITY INJECTION WELLS

There are no injection wells within a 2.5-mile radius of the NTI Facility.

VII.A.10 POTENTIOMETRIC SURFACE OF THE INJECTION ZONE

The potentiometric surface of the Injection Zone has not been characterized in the region of the NTI Facility. Original bottom-hole pressures are presented in Section VII.A.4. The expected static fluid level when the proposed injection well is completed is expected to be at 16.7 feet below ground level as calculated below.

Average Formation Fluid S.G. in Borehole (Section VII.A.3) = [1.0673/2] + [1.0267/2] = 1.047

BHP at 10,420 feet BGL (Injection Zone Midpoint) = 4,724 psi (Section VII.A.4)

Fluid Level = 10,420 feet – [(4,724 psi)/(1.047 x 8.34 x 0.052)] = 16.2 feet

From the geologic structure map (Figure V-24) of the Top of the Injection Zone, the direction of the dip is approximately east-southeast.

VII.A.11 ANTICIPATED GEOMETRY OF THE WASTE PLUME

The geometry of the waste plume is anticipated to be radial or circular. There is a fault mapped to the southeast of the of the injection well, however it is not anticipated that the fault will affect the anticipated geometry.

VII.A.12 EXTENT OF WASTE PLUME

The radial distance of displacement for the waste plume is typically calculated using the following equation (TWDB, 1983):

$$r = \sqrt{\frac{Q}{\pi h \phi}}$$

where:

r = radial distance of fluid front from well, ft;
Q = cumulative volume of fluid injected, cubic ft (ft^3);
ϕ = porosity of receiving formation); and
h = thickness of formation, ft.

In term of volumes measured in gallons (q), a conversion factor (0.13368 ft^3/gal) is used in the previous equation (q x 0.13368 = Q):

$$r = \sqrt{\frac{0.13368\ q}{\pi\ h\ \phi}}$$

An estimate of the influence of dispersion was made with the following equation:

$$r' = r + 2.3\sqrt{Dr}$$

where,

r' = radial distance of travel with dispersion, ft;
r = radial distance of travel without dispersion, ft;
D = dispersion coefficient, ft, for Dolomite is 65.

Using a formation thickness of 150 ft, a porosity of 9%, and a dispersion coefficient of 65, the plume radii following 1, 10 and 30-year operational periods at a constant injection rate of 102 gpm are presented in Table VII-2.

TABLES

TABLE VII – 1

ESTIMATED PRESSURE INCREASE OVER ORIGINAL PRESSURE

Time Period (Years)	Modeled Wellbore Pressure Increase (psia)
1 Year	132.56
10 Years	155.94
30 Years	167.14

TABLE VII – 2

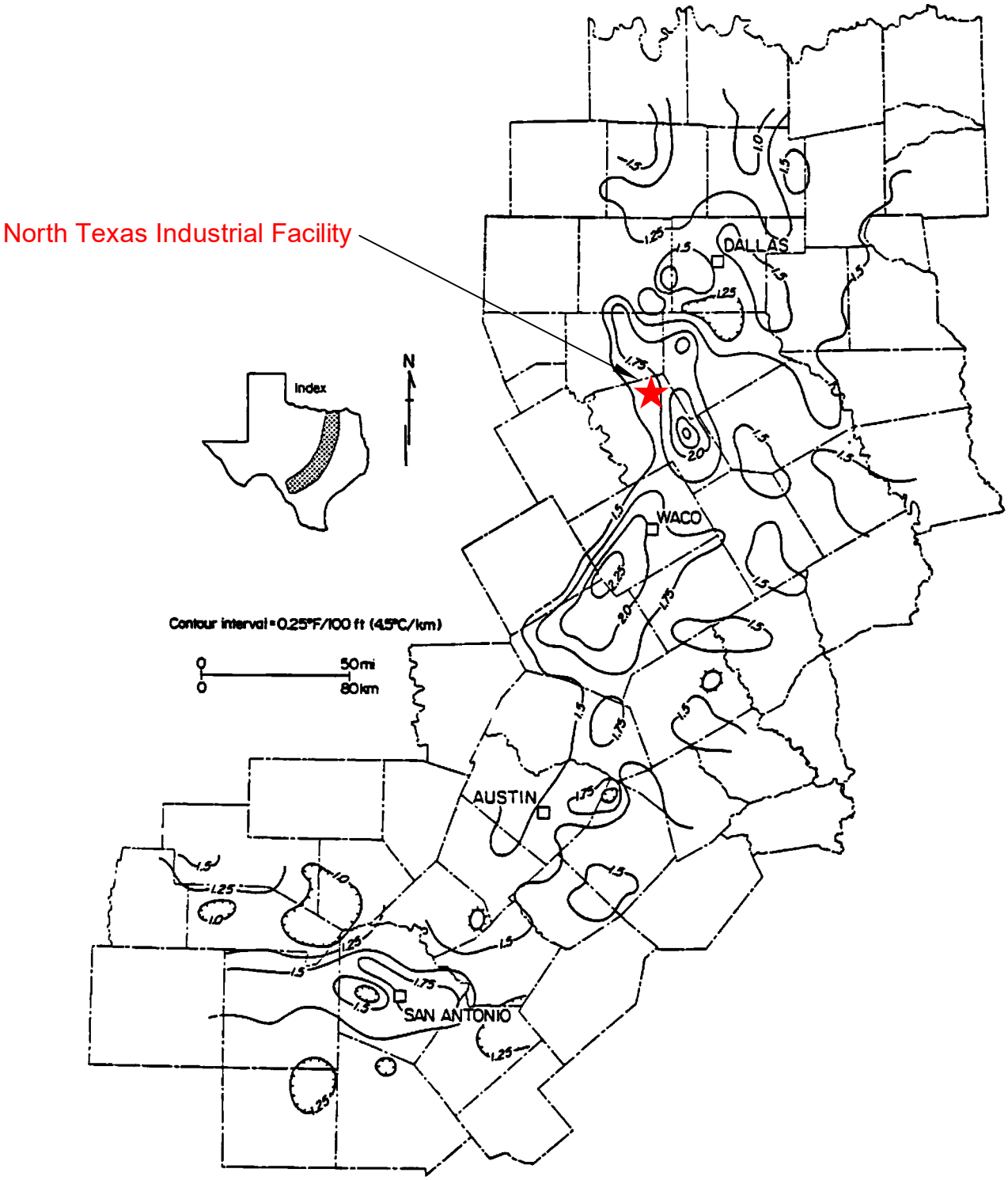
PLUME RADII EXTENT PROJECTION AFTER 30 YEARS OF CONTINUOUS INJECTION

Time Period (Years)	Cumulative Injected Volume (Gallons)	r (feet)	r' (feet)
1 Year	53,647,920	411	787
10 Years	536,479,200	1,300	1,969
30 Years	1,609,437,600	2,252	3,132

r' = radial distance of travel with dispersion, feet

r = radial distance of travel without dispersion, feet

FIGURES



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GEOTHERMAL GRADIENT MAP

Job No. 192128M

Drawn: WDD	Checked: JHL	Approved: RJS	Date: 11/08/2023	Scale: Above	Figure No. VII–1

Formation Compressibility, c_f

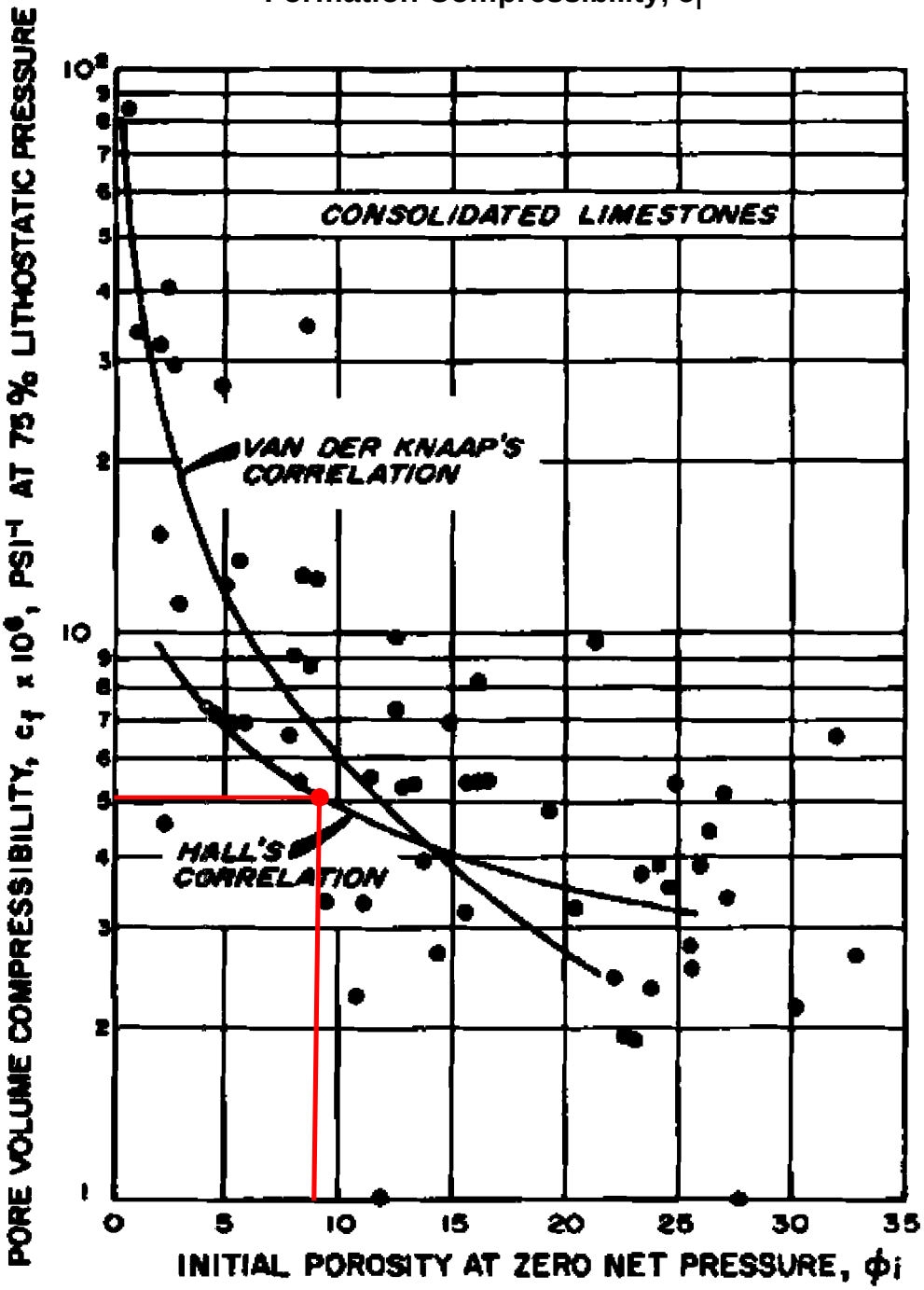

Fig. D.9 Pore-volume compressibility at 75-percent lithostatic pressure vs initial sample porosity for limestones. After Newman.[9]

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FORMATION COMPRESSIBILITY

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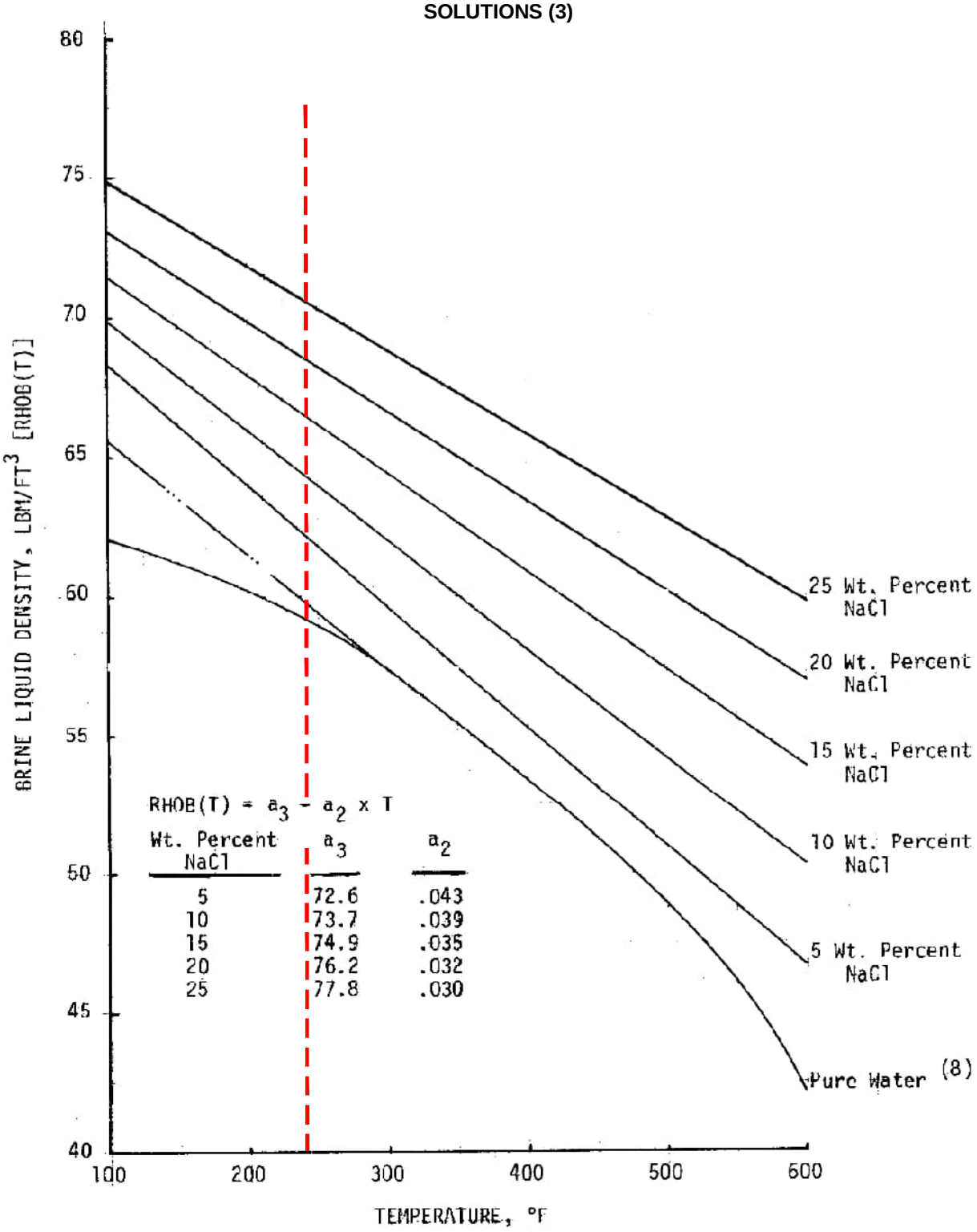
CALCULATED BRINE LIQUID DENSITY CURVES FROM DATA FOR DISSOLVED NaCl - H_2O SOLUTIONS (3)



Wt. Percent NaCl	a_3	a_2
5	72.6	.043
10	73.7	.039
15	74.9	.035
20	76.2	.032
25	77.8	.030

Modified from: Earlougher, R. C., 1977

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BRINE LIQUID DENSITY CALCULATION

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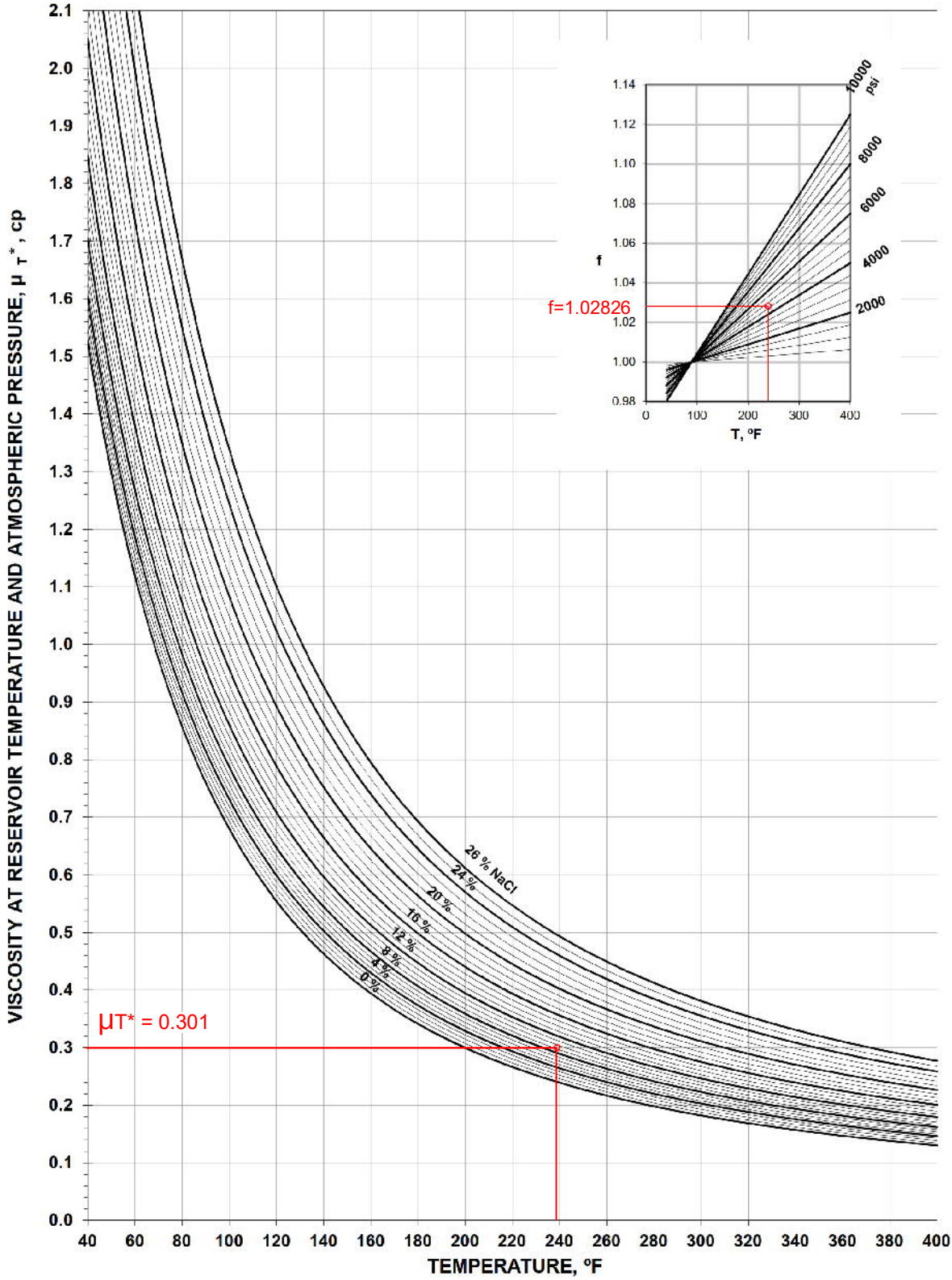
Water Viscosities at Various Salinities and Temperatures



Modified from: Earlougher, R. C., 1977

Developed from Equations provided in HP-41 Petroleum Fluids Pac

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VISCOSITY NOMOGRAM

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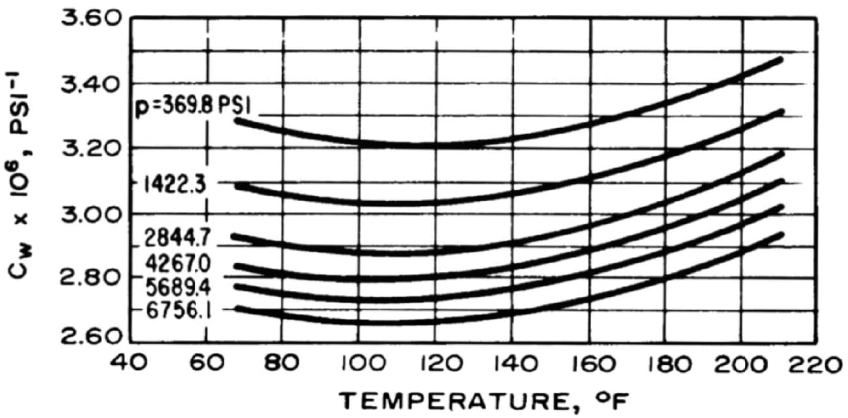
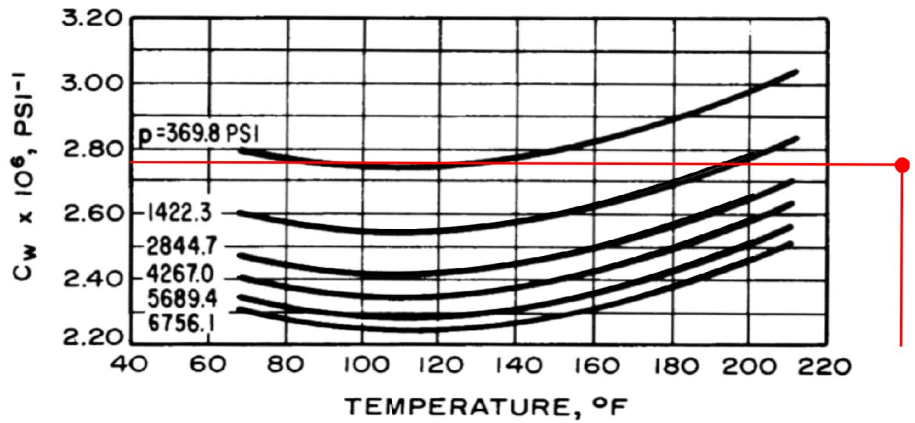
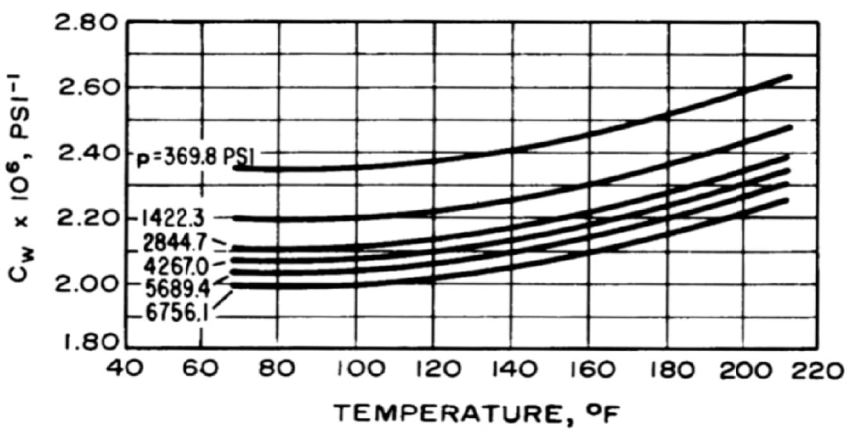


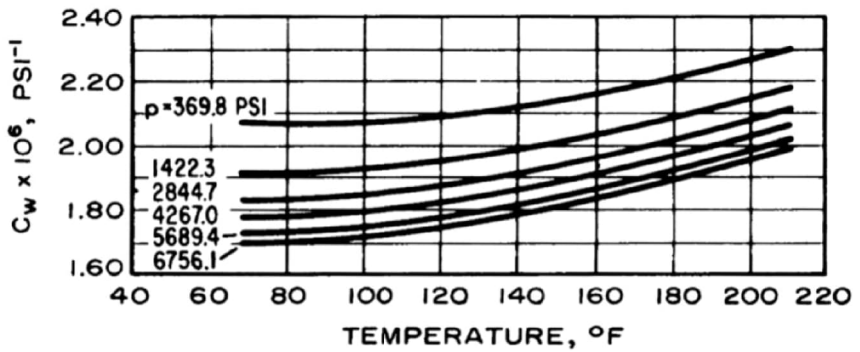
Average compressibility of distilled water.



Average compressibility of 100,000-ppm NaCl in distilled water.



Average compressibility of 200,000-ppm NaCl in distilled water.



Average compressibility of 300,000-ppm NaCl in distilled water

After Long and Chierici.

Modified from: Earlougher, R. C., 1977

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COMPRESSIBILITY OF WATER AND NaCL SOLUTIONS

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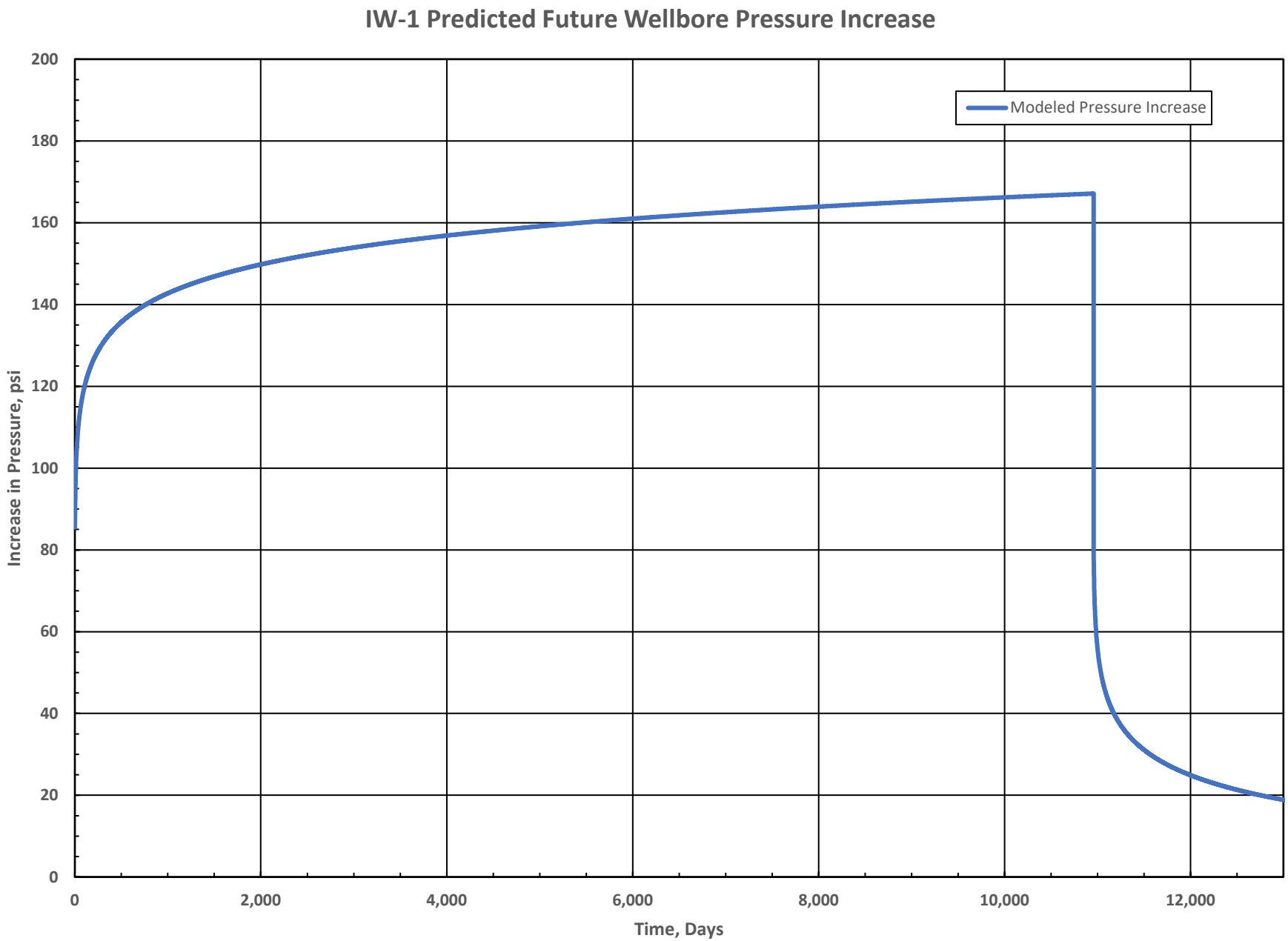
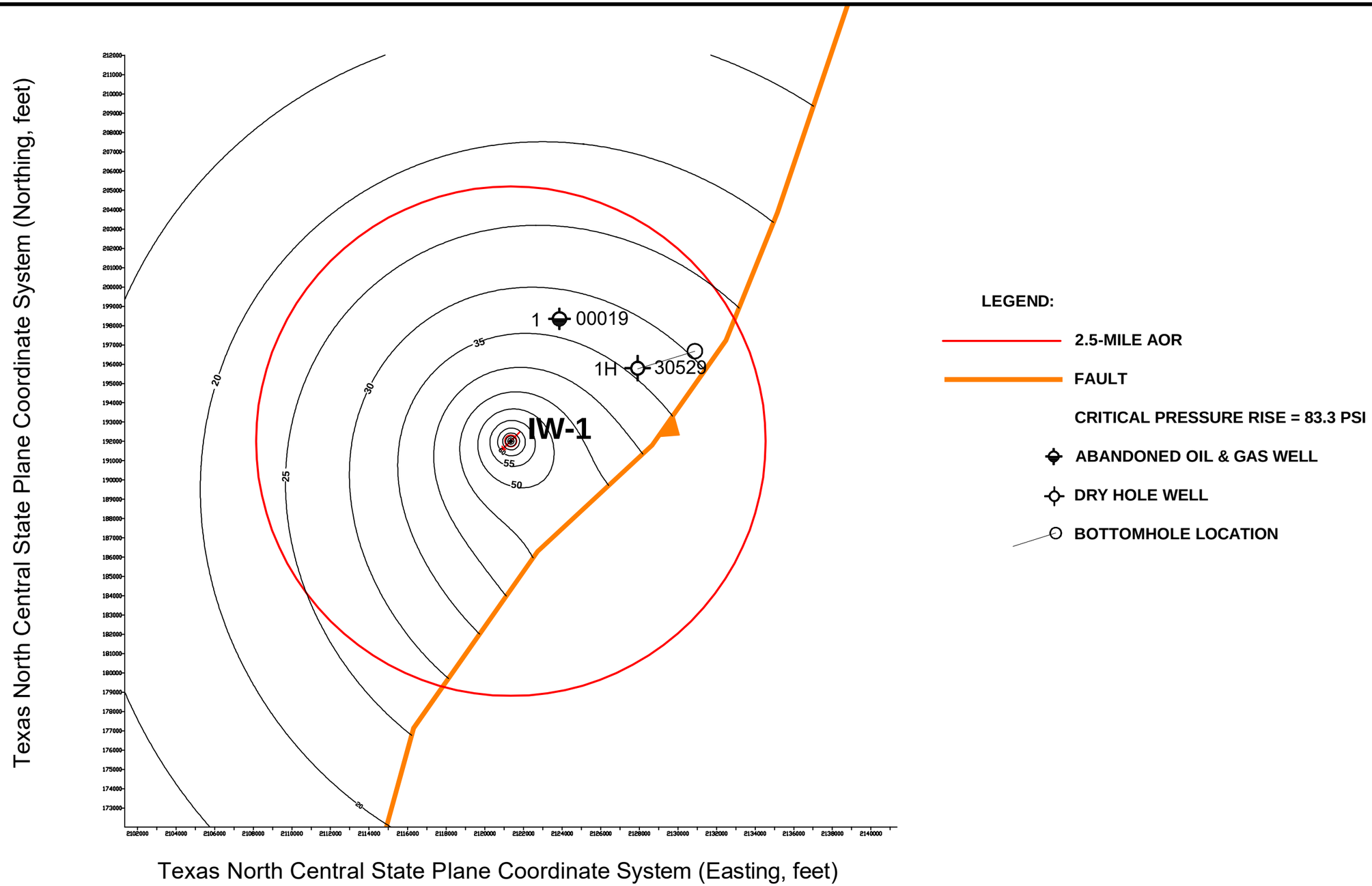

IW-1 Predicted Future Wellbore Pressure Increase
Modeled Pressure Increase
Increase in Pressure, psi
Time, Days
0
20
40
60
80
100
120
140
160
180
200
0
2,000
4,000
6,000
8,000
10,000
12,000

Figure VII-6



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NORTH TEXAS INDUSTRIAL FACILITY - IW-1
CONE OF PRESSURE INFLUENCE (1 YEAR OF CONTINUOUS INJECTION AT 102 GPM)

Job No. 192128M

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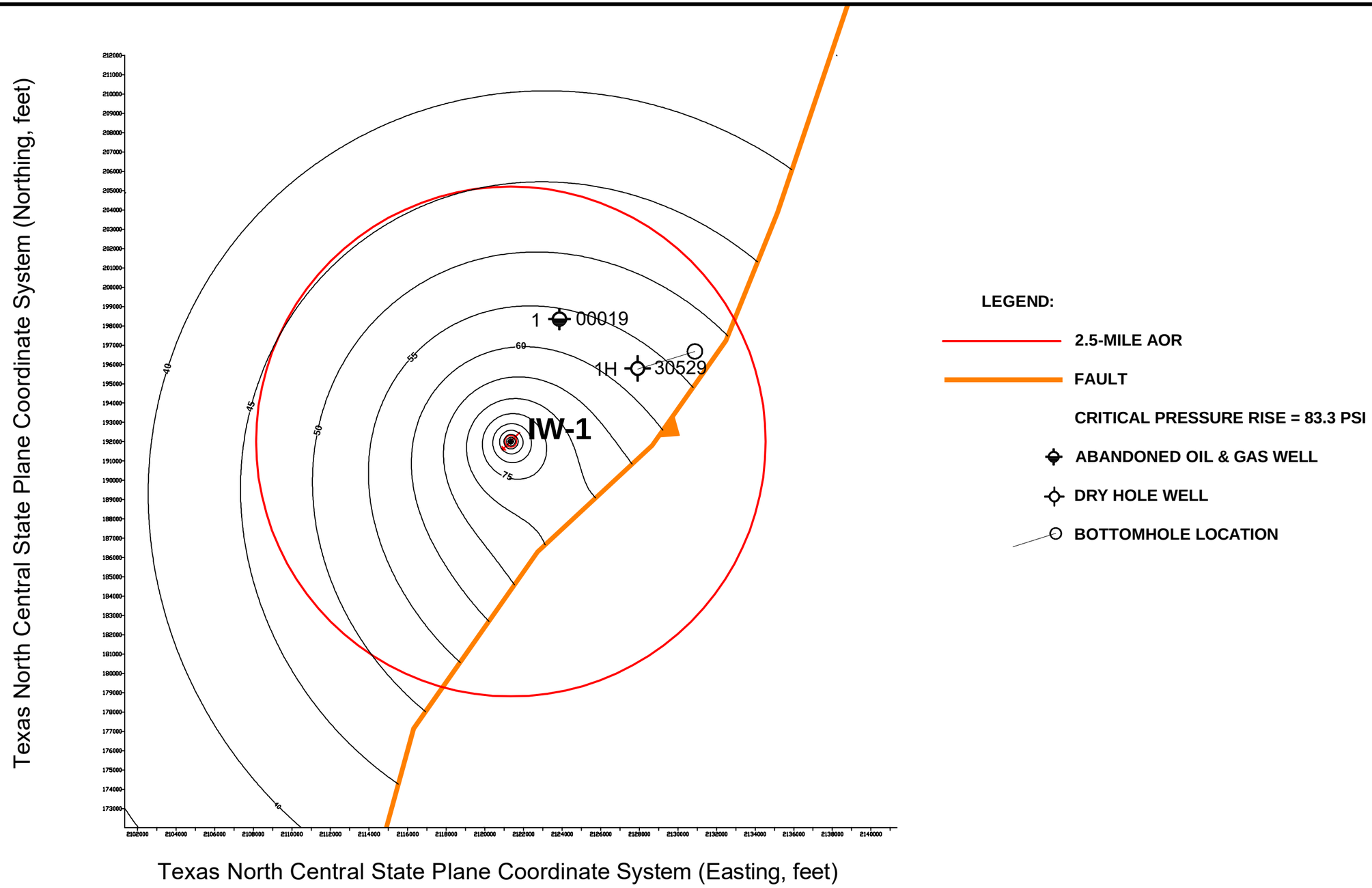
WDD	JHL	RJS	11/08/2023	NONE	VII–7



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NORTH TEXAS INDUSTRIAL FACILITY - IW-1
CONE OF PRESSURE INFLUENCE (10 YEARS OF CONTINUOUS INJECTION AT 102 GPM)

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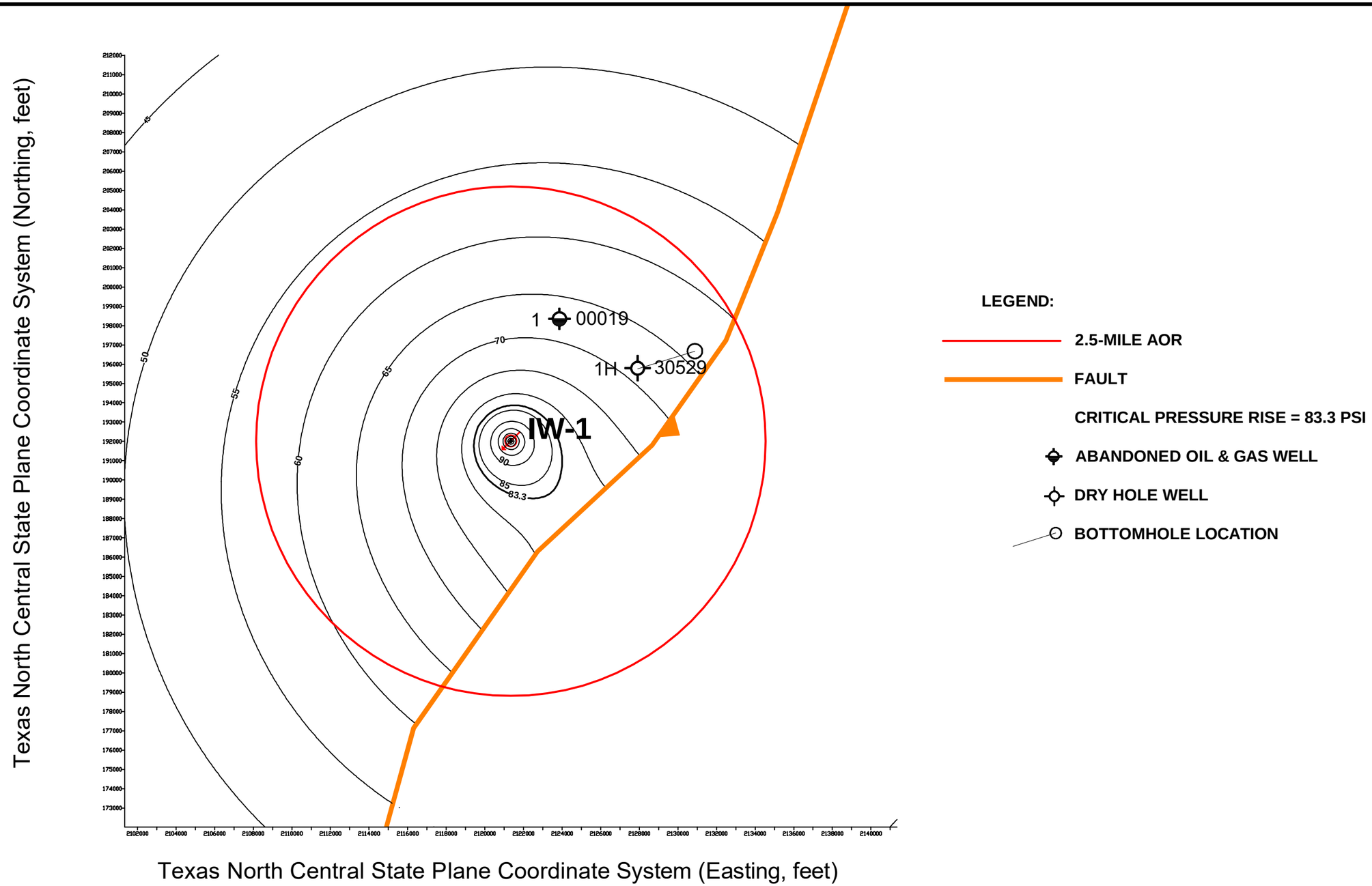
Drawn: WDD	Checked: JHL	Approved: RJS	Date: 11/08/2023	Scale: NONE	Figure No. VII–8



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NORTH TEXAS INDUSTRIAL FACILITY - IW-1
CONE OF PRESSURE INFLUENCE (30 YEARS OF CONTINUOUS INJECTION AT 102 GPM)

Job No. 192128M

Drawn: WDD	Checked: JHL	Approved: RJS	Date: 11/08/2023	Scale: NONE	Figure No. VII–9

APPENDICES

APPENDIX

VII-1 Texas Geothermal Assessment (Wilcox)

APPENDIX VII-1

Final Report

Texas Geothermal Assessment for the I35 Corridor East

FOR

Texas State Energy Conservation Office Contract CM709

Dr. David Blackwell, Maria Richards, and Patrick Stepp

Southern Methodist University
Roy M. Huffington Department of Earth Sciences
SMU Geothermal Laboratory
PO Box 750395
Dallas, Texas 75275-0395

March 29, 2010

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LIST OF ABBREVIATIONS

API - American Petroleum Institute
bbl - barrel
bbls - barrels
bbls/day - barrels per day
BCF - billion cubic feet
BHT - bottom-hole temperature
cm^3/sec - cubic centimeters per second
DOE - Department of Energy
EGS - enhanced geothermal system
EJ - exajoule (10^{18} joules)
FT - Feet (3.28 ft = 1 m)
gal/sec - gallons per second
GPM - gallon per minute
kg/s - kilogram per second
kW - kilowatt
m - meters
MA - million years ago
MMBBL/Day - million barrels per day
MW - megawatt (1000 kW)
PSI - pounds per square inch
RRC - Railroad Commission
TSC - time since circulation

EXECUTIVE SUMMARY

The impressive extent of the thermal energy available to Texans lying beneath the ground became evident through the 2004 publication of the Geothermal Map of North America. The high volumes of saltwater produced during hydrocarbon production, combined with the high temperatures found in Texas at depth, provide an ideal mix of resources from which to produce electricity from geothermal energy. Although previous investigations into the geothermal resource potential along the Gulf Coast led to a successful demonstration project in 1989-90, the business environment was not yet supportive of renewable energy (John et al. 1998) and the geothermal energy potential remained untapped. In 2010, we have a convergence of ideal economic forces, political climate, and technological advancements for using existing hydrocarbon production infrastructure as a means of generating baseload, renewable electricity for Texans.

Geothermal energy is a baseload renewable resource located in close proximity to where the majority of Texas citizens live. The development of this resource requires an understanding of both the business model and geologic structures involved. The existing infrastructure and expertise of the oil and gas industry in this area affords us the opportunity to leverage that investment and combine geothermal energy production with hydrocarbon and waste heat production. The interest from the business community is evidenced by the successful SMU Geothermal Conferences, which drew hundreds of participants, as well as by the number of companies installing systems throughout the Gulf Coast.

We achieved our stated project goal of defining geothermal resources through improved understanding of subsurface temperatures. The focus of study was the area of Texas generally east of Interstate 35 because of the overlap between high heat flow levels, the location of major Texas population centers, and the availability of numerous oil and gas field data. Both new and existing temperature data from oil and gas wells were collected, collated, and analyzed. Corrections to non-equilibrium BHT temperatures were compared with in situ well measurements to improve the accuracy of temperature readings.

Within the area of study, different temperature characteristics were observed by region. South Texas has the highest measured temperatures (in excess of 300˚F) at depths of 10,000 to 12,000 feet. The Gulf Coast geopressured areas have the most accessible energy potential, because of the large fluid volumes, entrained gas, and artesian flow. East Texas, while dominated by shallower drilling (typically less than 10,000 feet) and waterflood fields, possesses a crust with high natural radioactivity in the granites (such as is associated with the Sabine Uplift). This is indicates the elevated temperatures needed for geothermal energy can be expected at depth. The

drilling in North Central Texas is currently predominantly in the Barnett shale formation, averaging 7,000 to 8,000 feet. Beneath the Barnett shale formation, lays the Ellenberger limestone, which has temperatures in the 200 to 250˚F range and can produce water volumes in the 20,000 to 50,000 barrels per day range, based on injection well capacity. In short, all of the areas studied, while yielding different results, showed remarkable promise for geothermal energy potential.

In addition to the report detailing the extensive work done collecting, collating, and analyzing temperature data from oil and gas wells, we have included information from four conferences hosted by SMU on 'Geothermal Energy Utilization Associated with Oil and Gas Development'. As mentioned, a successful development of this resource requires an appreciation for the business potential as well as the geologic potential, which these conferences sought to combine. The full archive of the conference presentations and related papers are posted on the SMU Geothermal Laboratory website. Additionally, the website contains information developed to assist companies starting a geothermal project and a list of resources to contact for assistance.

The outcome of the temperature assessment work and the outreach projects, such as the conferences and web resources, has led to several projects in our general area reaching development stage. Among them:

- Universal GeoPower LLC and the U.S. Department of Energy (DOE) have a geothermal demonstration project in Liberty county, near Houston, designed to generate 250 KW of power using a watered-out and abandoned oil well from a Pratt & Whitney binary generation system.
- Louisiana Geothermal LLC and the DOE have a second demonstration project in Cameron Parish.
- Gulf Coast Green Energy, with a grant from the Renewable Partnership to Secure Energy for America (RPSEA), is deploying an ElectraTherm Green Machine in Jones County, MS on a Denbury Resources Inc. owned well that is expected to generate 30-50 KW.
- Hilcorp Energy Company and Cleco Power LLC are in development on a project in western Louisiana, also using the ElectraTherm Green Machine.
- The GeoPower Texas Company has acquired Texas General Land Office geothermal leases for development of off-shore wells near Galveston, Brazoria, and Matagorda Counties.

Conclusion: The next five years will be crucial to gain enough momentum to establish a geothermal industry in Texas. There are currently over 200,000 active wells in Texas. That is 200,000 potential sources of cost-competitive, renewable, baseload, clean energy to Texans. We have a window of opportunity to leverage our state's investment in the oil and gas industry while the economic forces, political pressures, and available technology are aligned towards a common goal of renewable energy. Additional resources of time and dollars would be well spent on exploiting the geothermal energy potential of Texas.

INTRODUCTION

For a century, Texas has been a leading energy producing state. Its abundance of oil and gas has sparked an energy industry unlike that of any other state. Sherk (1982) stated "To say that the State of Texas is rich in energy resources is roughly akin to saying that the sky is blue or the ocean is wet." Time has indeed demonstrated Texas is incredibly rich in both conventional and alternative energy resources. Geothermal resources in Texas are becoming increasingly viable. Since 1982 when Sherk made this statement, there have been advances in the geothermal and oil and gas industries which increase the compatibility of these industries. In fact, from the number of wells drilled since 1980, Texas now has 200,000 more reasons to develop geothermal energy[1].

Today the population of Texas is growing at a rate of 16%, creating a need for new sources of power[2]. This need has been reinforced by the rolling blackouts of 2007 and the request by TXU to build 13 new coal power plants in 2006[3]. With the development of geothermal energy power plants, the additional baseload renewable energy can help meet these ever increasing energy demands. In addition, increasing concern over air quality in Texas cities has resulted in a greater focus on alternative energy resources. Texas has shown leadership in renewable energy with its Renewable Portfolio Standard (RPS). The 2005 RPS increase from 2,000 MW to 5,880 MW stimulated a historic explosion of wind energy development, and Texas is now the largest developer of wind energy in the United States[4]. The goal for more renewable energy motivated this resource evaluation of geothermal energy as a source of electrical production.

Geothermal energy is a baseload renewable resource with a consistent capacity to compete with nuclear, natural gas, and coal power plants. Existing technology allows it to be scalable and configured either as distributed or centralized energy sources, making it local and capable of being installed inside or close to population centers. It utilizes the current knowledge base of the oil and gas industry, creating a new green industry for Texas while simultaneously keeping the

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[1] http://www.rrc.state.tx.us/

[2] http://quickfacts.census.gov

[3] Dallas Morning News, September 01, 2006

[4] http://www.seco.cpa.state.tx.us/re_wind.htm

existing hydrocarbon service industry productive long after the wells cease to produce hydrocarbons. Geothermal development can also enhance Texas' ability to produce hydrocarbons at lower costs, for longer periods of time, and to extract gas in locations where it is presently uneconomic. Areas in Texas with the greatest geothermal potential directly correlate with the active hydrocarbon production areas of the eastern and southern portions of the state. They are located near the large urban areas of Dallas-Fort Worth, Houston, San Antonio, and Corpus Christi. The majority of oil and gas fields in these regions are connected to the power grid, with existing major transmission lines often directly overhead allowing for convenient grid connections for the geothermal power development to use the existing power line system.

This geothermal assessment focuses on temperature mapping of wells with depths of over 7000 feet, capable of electrical generation in the eastern half of Texas (located between interstate I-35 and the eastern border of Texas). This area covers North, East, and South Texas, as well as the Texas Gulf Coast. This regional focus was chosen because of the collocation of existing oil and gas fields with higher heat flow areas (Figure 1) as shown on the Geothermal Map of North America, (Blackwell and Richards, 2004a) and described in general resource analyses by Blackwell et al. (2006) and Negraru et al. (2008). The assessment of existing and new temperature data, along with the changes in geothermal technology, illuminates the compelling reasons Texas has for developing its geothermal potential.

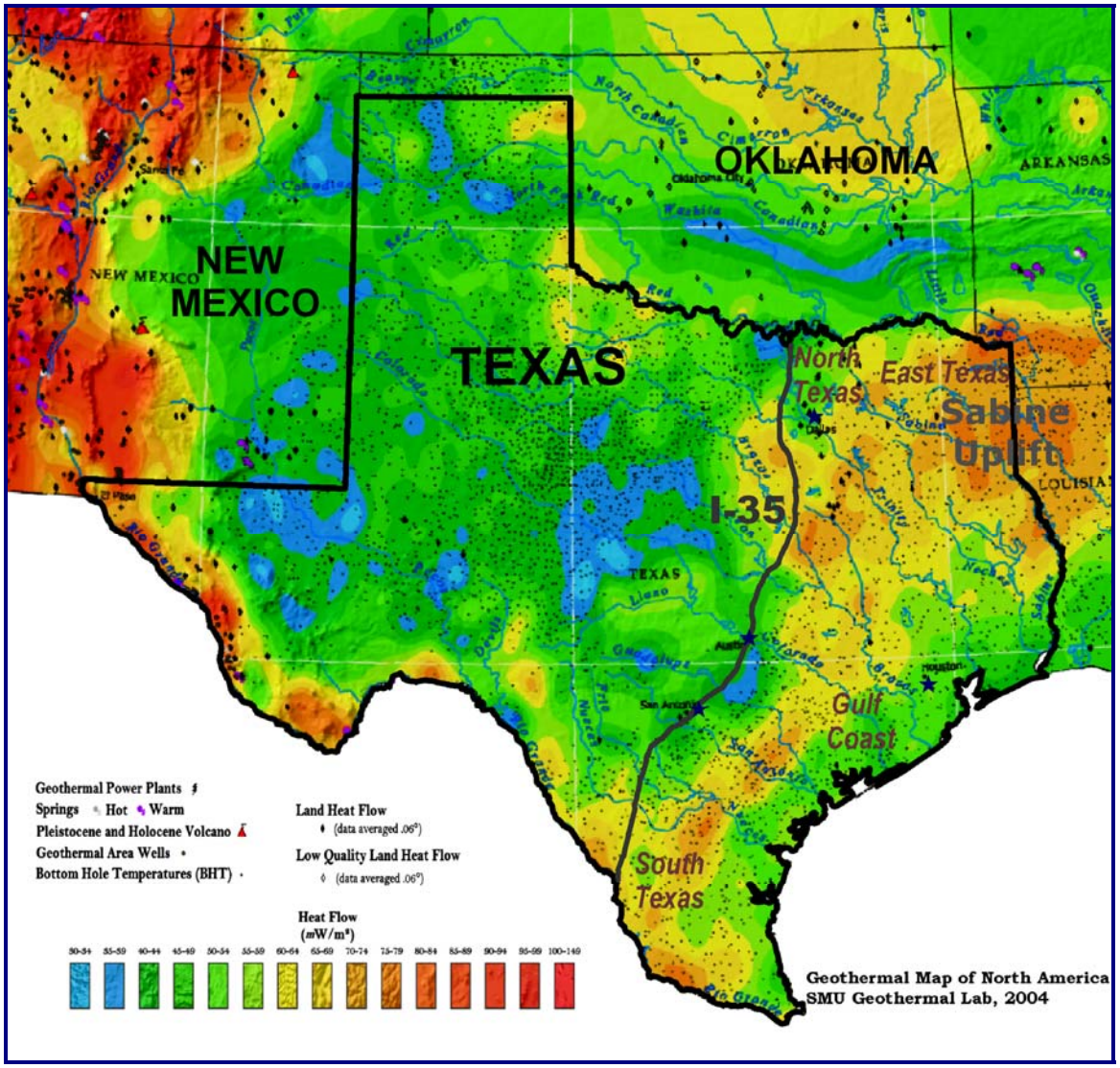

Figure 1. South-central portion of the Geothermal Map of North America (Blackwell and Richards, 2004a) with the Texas State boundary highlighted and the areas discussed in report.

OVERVIEW OF PREVIOUS REPORTS

Geothermal power production could be at the leading edge of Texas energy development for this century. Texas has been building its geothermal resource knowledge base since the early 1900s, as shown by temperature data collected by Plummer and Sargent (1931) and Spicer (1964) from early oil wells typically between 2500 and 5000 feet deep.

Starting in the mid 1970s, the oil embargo resulted in concentrated studies of geopressured - geothermal resources in Texas. Grants of approximately $200 million were awarded by the U.S. Department of Energy (DOE). The primary goals of these studies were to: define the extent of the geopressured reservoirs; determine the technical feasibility of reservoir development, including downhole, surface and disposal technologies; establish the economics of production; identify and mitigate adverse environmental impacts; identify and resolve legal and institutional barriers, and determine the viability of commercial exploitation of this resource (John et al., 1998). This previous research revealed massive geothermal and geopressured resources in Texas. It concluded with the successful demonstration of geopressure electrical generation conducted by the DOE at Pleasant Bayou, Brazoria County in 1989-90 (Shook, 1992; John et al., 1998). Technical feasibility was demonstrated, but momentum was lost during the period of low energy prices between 1985 and 2003.

As part of the geothermal studies C.M. Woodruff investigated geothermal energy in central Texas throughout the 1970s to the early 1990s. His research focused primarily on the mid-depth ranges of geothermal resources (5000 feet to the surface), and aquifers associated with low to moderate temperatures (70 to 150°F), useful for direct use applications and not electrical power generation. Woodruff wrote the first Geothermal Resource Assessment for the State of Texas in 1980 and produced the Geothermal Map of Texas in 1982. Much of his research focused on to the Balcones, Luling, Mexia, and Talco fault zones with an evaluation of hydrologic properties of Cretaceous aquifers located in North and Central Texas and low-temperature development for direct use applications (Woodruff and McBride, 1979), such as heating hot water in the community hospital in Marlin, Texas (Woodruff et al., 1982).

More recent studies/research focus on regional heat flow off-shore in the Gulf of Mexico (Nagihara and Jones, 2005; Nagihara and Smith, 2008) and as part of the Geothermal Map of

North America (Blackwell and Richards, 2004a); a review of the geothermal resources in the South Central portion of the United States (Negraru et al., 2008); and the use of Enhanced Geothermal Systems (EGS) in the United States with each individual state's resources categorized (Tester et al., 2006; Blackwell et al., 2006). Additionally, a resource study of oil and gas well data examines the geothermal resource potential in West Texas (Erdlac, 2006).

These studies prove conclusively that geothermal resources exist. Geopressure continues to be viewed as an integral part of the Texas geothermal resource. A search for "geopressure and Texas" on the Office of Science and Technology Information website, results in over 300 publications[5]. As a single option, the geopressured resource holds the largest potential for electrical development in Texas. Geothermal understanding of this geopressured resource has changed little since the completion of studies in the 1990s, but technology and energy economics have continued to evolve. Therefore, past geologic research is of the utmost importance as a knowledge base for this and any future geothermal assessment or development project. A review of the multiple geopressure related publications and references is provided in Appendix A.

GENERALIZED REGIONAL GEOLOGY

Throughout geologic time Texas has experienced multiple periods of uplift and regional seas covering the surface creating the numerous layers of sediments. The depth to basement determines the maximum thickness of sedimentary layers, and therefore the maximum depth of drilling for oil and gas wells. The eastern half of the state was part of the collision between the North American tectonic plate and the Europe-African-South American plate that formed the supercontinent Pangaea. This event folded and faulted the sediments now exposed in the Appalachian Mountains, the Ouachita Mountains in southwestern Arkansas and southeastern Oklahoma, and the Marathon region near Big Bend National Park in West Texas. Originally a mountain chain extended through the zone of deformation between the Ouachitas and Big Bend around the Llano uplift, the region is now covered by younger sediments and the exact nature of these rocks is not known. Today these buried "mountains" form the basement rocks under much of Central Texas as part of the Ouachita Overthrust Belt (Figure 4).

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[5] http://www.osti.gov

As North America rifted away from Europe/South America during the break up of Pangaea, fault zones formed which still impact Texas. The Balcones fault zone was created along the Texas Craton and slightly further south-east the Luling - Mexia fault zones were created. Today these are zones of weakness that allow warm fluids to rise quickly along them and create elevated temperatures in the deeper fresh water aquifers, such as the Trinity, Hosston, and Edwards (Woodruff et al., 1982). The newly formed East Texas and Gulf Coast basins were buried by thick deposits of Middle Jurassic marine salt and sediments. Igneous oceanic crust formed in the Gulf Coast Basin during the Late Jurassic. The boundary between oceanic and continental crust lies beneath the present-day Texas continental margin, but its exact location is unknown. Jurassic and Cretaceous deposits formed broad carbonate shelves that were periodically buried in places by deltaic sandstones and shales at the edge of the widening Gulf of Mexico. Mobilization of the salt from evaporates formed salt domes in East Texas and the Gulf Coast. The deposition along the Texas Gulf Coast continental shelf continued to build new land mass towards the Gulf of Mexico, as it continues to do today. Area of deposition shifted over time across the Gulf Coast. The sediment flow was dominated from the western side of the Gulf Coast (now South Texas and Central Gulf Coast) during the Eocene and Oligocene (~55 - 23 MA). It gradually shifted eastward, where it is today with sediment primarily from the North and East (Mississippi Delta) (Salvador, 1991, Figure 2).

Sea level has fluctuated continuously throughout the geologic past. During the most recent glacial advances, the sea levels were 300 to 450 feet lower than today (an interglacial period), because so much sea water was contained in the ice sheets. The climate was both more humid and cooler than that of today, and the largest Texas rivers carried more water and sediment to the Gulf of Mexico. These deposits underlie the initial fifty miles or more of the Gulf Coastal plain inland from the current shoreline. Approximately 3,000 years ago sea level reached its modern position, and the coastal features that are present today, such as the deltas, lagoons, beaches, and barrier islands, have formed since that time (Sellards, et al., 1933).

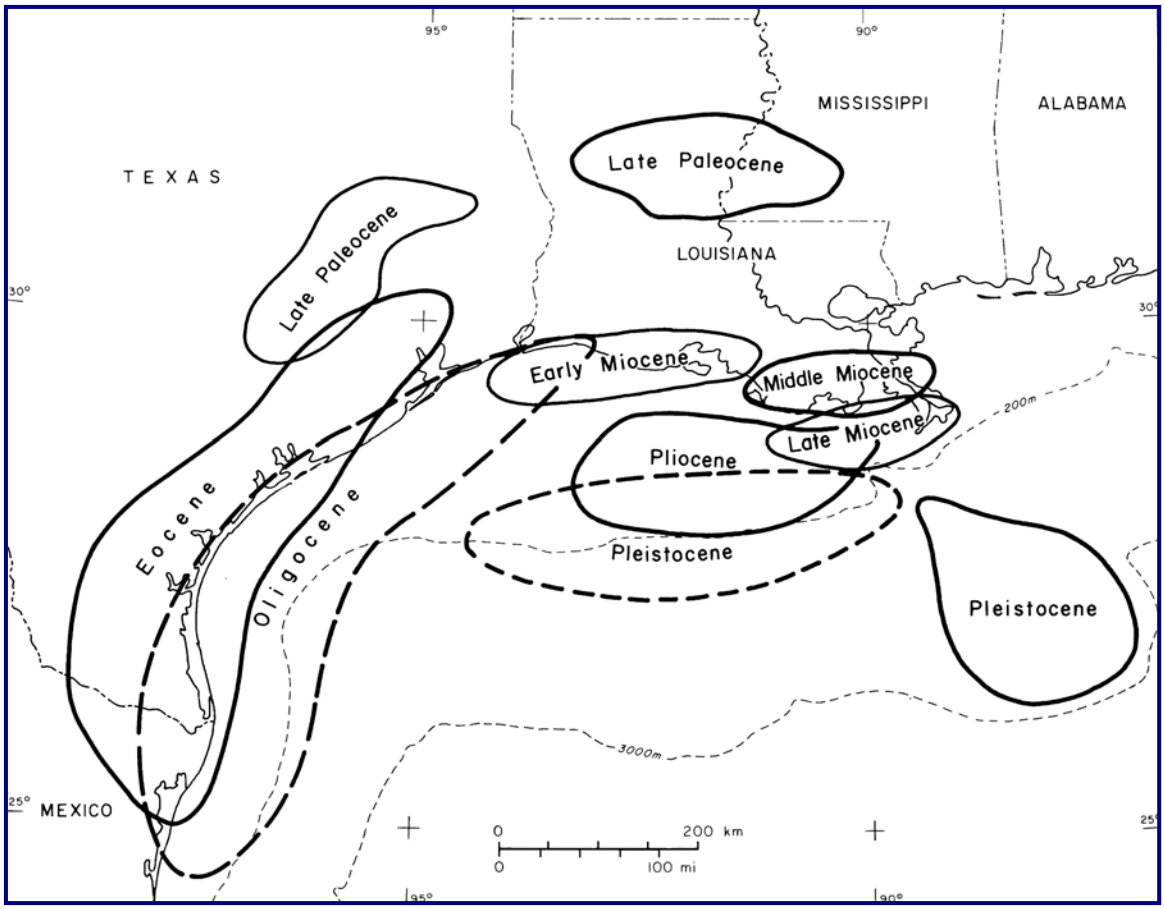


Figure 2. Location of Cenozoic depocenters, northwestern Gulf of Mexico from oldest to youngest: Late Paleocene, Eocene, Oligocene, Early to Late Miocene, Pliocene, Pleistocene, (Salvador, 1991).

Gulf Coast Geology

The Gulf Coast is known for its geopressured - geothermal resources located along the coastal regions of both Texas and Louisiana. The region is approximately 100 miles (160 km) wide and 750 miles (1,200 km) long onshore and encompasses roughly an equivalent area offshore (Wallace et al., 1979; Davis et al., 1981). The pattern of geopressured formations in Texas consists of roughly concentric bands of sediment, trending parallel to the Gulf of Mexico coastline. The regional dip is Gulfward, with formations becoming progressively younger and thicker in the downdip direction towards the Gulf Coast.

The formation of geopressured strata along the Gulf Coast resulted from the rapid sediment deposition over the last 65 million years at each successive position of the continental margin into the rapidly subsiding Gulf of Mexico basin. Sequences of prograding deltas deposited sand on top of unconsolidated shales (water-laden clays and silt) and salt deposits. The weight of the

overlying sands caused large scale slumping along growth faults and the sands became hydrologically isolated by the surrounding, less permeable shales. With progressive burial, the pressure of the saline fluids trapped within the sandstones increased, becoming greater than hydrostatic, (0.465 psi/ft) and eventually approaching lithostatic pressure (~1.0 psi/ft, Davis et al, 1981). As a result of the high pressure, the sands are very porous and permeable for their depth. These geopressured sands contain entrained methane. Wells drilled into this geopressured sand flow artesian (naturally) to the surface. Water temperature can range from 190°F (88°C) to over 400°F (205°C). This water is an important resource because it contains three forms of energy: 1) *thermal* from the high temperatures; 2) *hydraulic* from the high fluid flow pressure; and 3) *chemical* from the dissolved methane in the fluids.

A number of distinct clastic wedges within the Gulf Coast have been identified for their resource potential in the onshore portion of the geopressured zone. Foremost among these are the Upper Claiborne Group, Wilcox Group, Vicksburg and Frio Formations (Figures 3 and 4).

SYSTEM	SERIES	GROUP/FORMATION
Quaternary	Recent	Undifferentiated
	Pleistocene	Houston
Tertiary	Pliocene	Goliad
	Miocene ? ?	Fleming
		Anahuac
	Oligocene	Frio
		Vicksburg
	Eocene	Jackson
		Claiborne
		Wilcox
		Midway

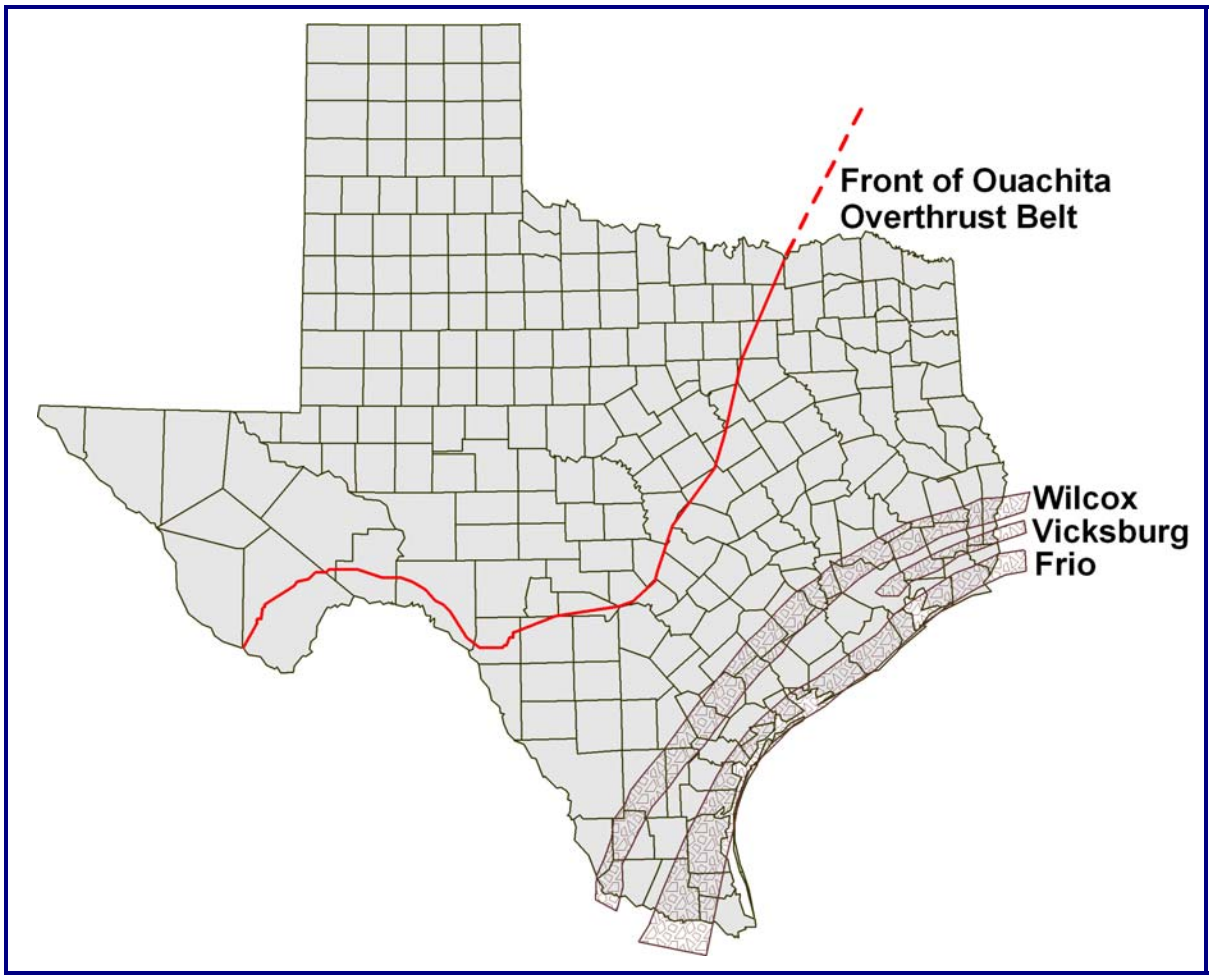


Figure 4. Geothermal corridors of primary geothermal favorability at depth shown in brown fill. (Bebout et al., 1983). Front of the Ouachita Overthrust Belt is drawn as a solid line in Texas and dashed in Oklahoma to represent it continues beyond the boarder and on into Arkansas.

East Texas Geology

The East Texas embayment (basin) and the Sabine uplift (Figures 1, 5, 6) are the dominating structures of East Texas and northwestern Louisiana. The sediments filling the East Texas embayment are the oldest of the Gulf Coast sequence with most being Cretaceous and Jurassic in age. The Paleozoic basement rock in this area appears to have higher levels of natural radioactivity than the basement rock in Texas north and east of the Ouachita belt (Negraru et al., 2008). As a result the heat released increases the geothermal gradient in the overlying sediments in the vicinity of the Sabine Uplift (Figures 1 and 5).

East Texas and the Gulf Coastal area are also known for various types of salt bodies (Seni and Jackson, 1983) (Figure 6). The layers of salt formed during the Middle Jurassic (~170 MA),

when the area fluctuated from an inland sea to land. The salt formations were deeply buried by the accumulating sediments, but the less dense salt could migrate through the upper sedimentary layers forming prominent subsurface features such as: diapirs, horizontal tongues, and domes. As the salt moves, it forms significant traps for the maturing oil and gas in the sediments. Local thermal anomalies are formed around the salt bodies because the salt has a very high thermal conductivity compared to the surrounding sediments.

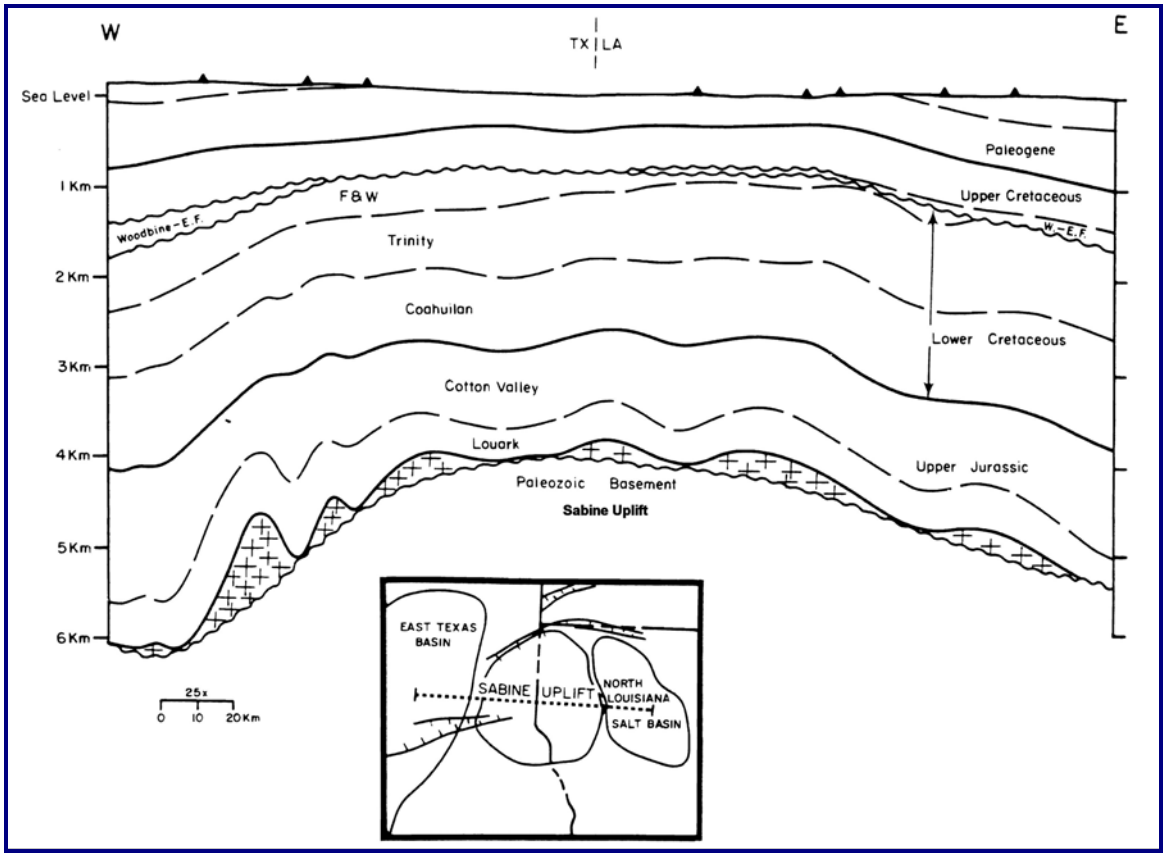


Figure 5. A geologic cross-section of East Texas through western Louisiana (Salvador, 1991). The Sabine Uplift is shown as the Paleozoic Basement rocks at the bottom of this cross-section. The location of the cross-section is also drawn on Figure 6 as a blue line.

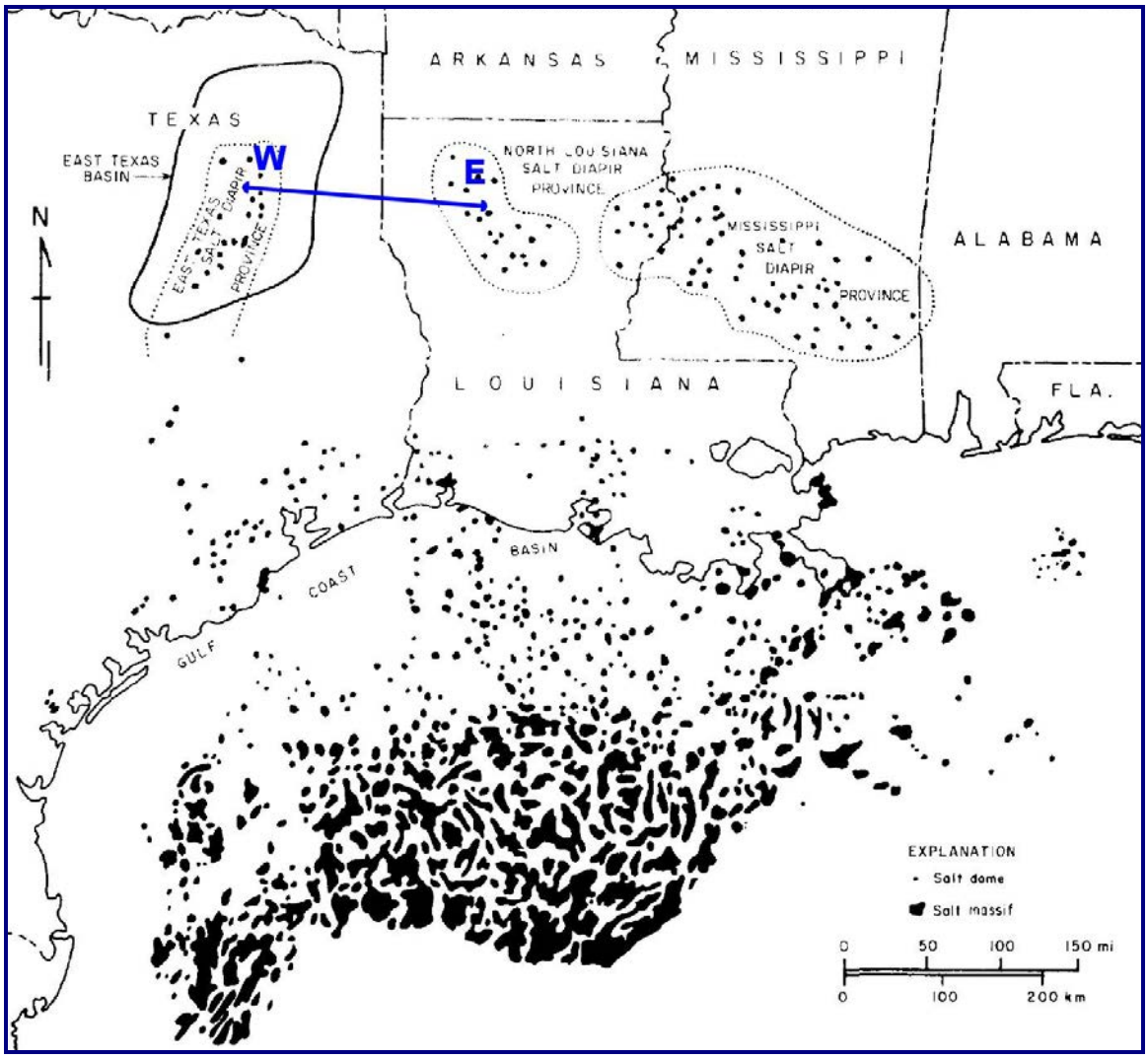


Figure 6. Map of East Texas basin, location of inland salt-diapir provinces, and salt domes, (Seni and Jackson, 1983). Cross-section in Figure 5 is shown as a blue line.

DATA COLLECTION METHODOLOGY

The temperature data used in this assessment consists of five data sets with locations shown in Figure 7 and the data overview in Table 1. Appendix B contains the raw data. The SMU Geothermal Laboratory Texas Railroad Commission Oil/Gas Temperature data (SMU-TX RRC) database is a new result of this assessment. The data were extracted from well log headers downloaded from the Railroad Commission (TX-RRC) website[6]. The assessment area is within

[6] http://www.rrc.state.tx.us/

the TX RRC Oil and Gas Districts 1 though 6. The SMU-TX RRC database contains the following information on 4,887 wells: 1) latitude and longitude (NAD 27); 2) county; 3) API and TX RRC surface and bottom well ID numbers; 4) type of well (oil/gas/both) and production status as of 2006; 5) bottom hole temperature (BHT); 6) depth of measurement; 7) elevation; 8) time since circulation; 9) field name and operator. SMU-TX RRC data are mostly from wells drilled during the 2000s, with some wells from the 1990s. As such, this database reflects a snapshot of current drilling activities in the eastern portion of Texas and is a random dataset based on availability of well logs on the TX RRC website.

The second largest dataset available is the Texas subset of the American Association of Petroleum Geologist (AAPG) Geothermal Survey of North America GSNA) Well Data (AAPG, 1994). This dataset was collected for the United States as part of the Geothermal Gradients Map of North America (DeFord and Kehle, 1976) from oil and gas wells drilled before 1972. This database includes 2,498 wells that are used in this assessment.

The key difference between the two oil and gas databases is the areal distribution of the data. The SMU-TX RRC data were collected using current online information based on what was submitted. As a result there are clusters of data in fields where many new wells were drilled and other areas with few points. The AAPG Geothermal Survey Well Data were collected on a more even distribution. Because of this difference in approach, it is possible to create maps both on a regional scale and, in some instances, at a local county-field scale.

Other data sets used include the Gulf Coast Geopressure data (Gregory et al., 1980), the Hunt Oil Company Fairway Field data in Anderson and Henderson Counties (Hunt Oil and Kweik, this report), the Freestone County well data (Burns, 2004) and the USGS GEOTHERM shallow database (Bliss, 1983).

The Gulf Coast Geopressure data (Gregory et al., 1980) include 654 well data points with the following available parameters: well number, total depth, bottom-hole temperature (BHT), formation, sand thickness, porosity, fluid pressure, water salinity, and methane solubility. The report data were converted to digital for this and future studies. These data are helpful in modeling 3-D aspects of the Gulf Coast because of the included geologic information.

The Fairway Field (located in Anderson and Henderson counties) data were collected for this assessment through collaboration with Hunt Oil Company. Well data were collected from the Hunt Oil Company files to characterize the thermal regime, review the history of the field and to investigate possible changes in temperature over time. The data collected include 216 wells with production data, 2,241 pressure tests, and 30 wells with injection data. These wells were drilled over a 40 year period from 1965 to 2005.

A previously detailed thermal study was completed on Freestone County as part of a SMU Masters Thesis (Burns, 2004) with the well data collected from oil and gas well log headers. There are 174 well locations with some wells having up to four interval temperature measurements.

The USGS GEOTHERM shallow database for Texas (Bliss, 1983) was sent to us for inclusion in this assessment by Janet Abbot of Spa Waters of Texas, who has some of the original data records. The data set contains primarily shallow wells (<5,000 ft) and spring chemistry data. Because these wells are shallow and therefore not suitable for electrical production, they were not used in the resource evaluation. This data set is included in Appendix B.

Table 1. Data set information used in this assessment.

Name of Data Set	**Author, year**	**Number of Wells**	**Area of Coverage**
SMU Geothermal Laboratory Texas RRC Oil/Gas Temperature Database	SMU, 2009	4,887	RRC Districts 1 - 6
AAPG Geothermal Survey Well Data	AAPG, 1994	2,498	North America
Gulf Coast Geopressure	Gregory et al., 1980	654	Texas Gulf Coast
Freestone County Well Logs	Burns, 2004	174	Freestone County
Hunt Oil Fairway Field	Kweik, 2009	216	Anderson and Henderson Counties
USGS GEOTHERM	Bliss, 1983	1,120	Texas

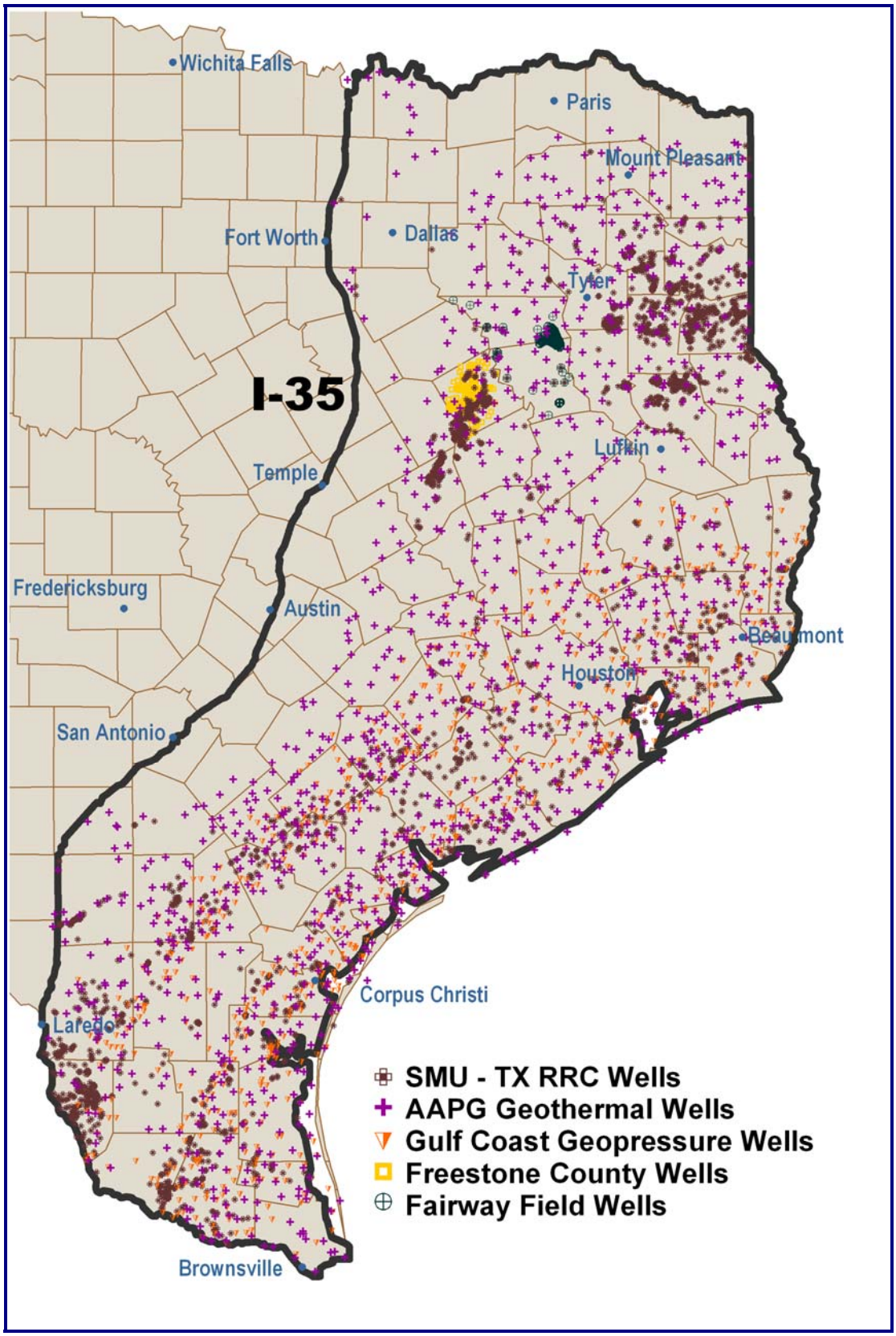


Figure 7. The locations of different data sets used in this assessment.

DATA CORRECTIONS

The temperature data in this assessment are from oil and gas wells. In order to give value to the data, multiple steps were taken to determine well data accuracy and correct for differences in raw data versus in-situ temperatures. In a best case scenario, the temperatures would be from measurements of wells at equilibrium with high precision, high resolution equipment (Wisian et al, 1998). This is rarely possible. To improve the value of the collected data, corrections were made to the data and comparisons of the corrected data were made with more accurate methods. This section describes the data and these corrections and comparisons.

While drilling a well, fluid is injected and circulated from the surface to the drill bit in order to cool the bit, stabilize the borehole walls, and clear the cuttings from the borehole. The mud and fluids impact the surrounding rock formations, thereby cooling the borehole at the deeper depths and potentially heating it in the shallow depths depending on the surface air temperature, drilling speed, type of drilling fluid, etc. Most wireline logging tools have maximum reading thermometers included with the other data recorders. Logging of the well usually occurs after initial drilling ceases and before the well section is cased. Therefore, an individual well can have more than one bottom-hole temperature (BHT) measurement, making these interval maximum temperature measurements in some cases.

For a well to return to the original, in-situ temperature, there is a period of equilibration. Many factors can affect the time needed for this process to occur. Some of these factors include the thermal conductivity of the rock formations, pore fluid movement, and drilling times and conditions. The process of re-equilibration generally takes several times the period of time the drill bit was at or below the point of measurement (Harrison and Luza, 1985). To adjust for these differences the well log header temperatures (BHT) are given a correction as discussed in the following section. The data included in this assessment are available in spreadsheet format in Appendix B.

Data Review

The Fairway Field data were acquired from the in-house files of Hunt Oil Company. This allowed for the collection of different types of available well log data not often readily available in the public domain (pressure, injection, production) from the up to 40 years of production.

Within this data set, if a well had multiple temperatures collected at the same depth, the temperature used was determined by repeatability of the value and the temperature of nearby wells.

The other existing datasets used [AAPG Geothermal Survey Well Data, Gulf Coast Geopressure, and Freestone County Wells] were already reviewed for errors by their respective authors. Next, the SMU-TX RRC data were combined with the other data sets and compared within a 1° by 1° area for similar temperatures and depths between the different data sets. Wells with temperatures greater than the local standard deviation (±27°F) were removed as outliers and noted in the database.

Temperature Correction

There are various types of temperature corrections that can be applied to the BHT value to calculate the approximate in-situ temperature. This is usually done based on the time since circulation recorded with the BHT reading, or derived from an empirical correction based on the depth of the measurement. The Gregory et al. (1980) report states the Harrison correction was applied to the temperature values to represent in-situ values. This same correction was used previously by Blackwell and Richards (2004a) on the Geothermal Map of North America, and Harrison et al. (1983) for oil and gas wells in Oklahoma. This correction is similar to the correction used by Kehle et al., (1970) for the Geothermal Gradient Map of North America (Equation 1). The correction used by SMU Geothermal Laboratory is based on the Harrison correction, which is a second order polynomial that correlates the BHT measurement to depth (Equation 2). It was applied to the SMU-TX RRC data, AAPG Geothermal Survey Well data, Freestone County Well data, and Fairway Field data using SMU-Harrison Equation 1. This correction value is then added to the well log header BHT measurement to calculate an approximate in-situ temperature.

Kehle Correction Equation 1. $\triangle\ °F = -8.819 \times 10^{-12} z^3 - 2.143 \times 10^{-8} z^2 + 4.375 \times 10^{-3} z - 1.018$

where z = depth in feet. (Gregory et al., 1980, p. 59).

SMU-Harrison Equation 2. $\triangle\ °C = -16.51213476 + 0.01826842109\ z - 0.000002344936959\ z^2$

where z = depth in meters.

A comparison of the SMU-Harrison equation and the Kehle equation shows the largest difference at shallow depths, i.e., 4.5 °F at 6,000 feet, with the SMU-Harrison correction the lesser of the two. At depths of 12,000 feet or greater, the corrections are the same. The SMU-Harrison equation is used to correct BHTs between the depths of 3,000 and 12,900 feet. Deeper than 12,900 feet the BHT data were given a linear increase starting with the maximum value of the SMU-Harrison correction (34.3°F) and increasing slightly by 0.05°F every 500 feet. The deeper wells are expected to have longer times between drilling circulation and BHT measurements. As a result, the correction is assumed to not increase at the same rate as the shallower depths.

In order to assess the validity of the calculated in-situ temperature, the values were checked against wells in Texas logged by the SMU Geothermal Laboratory. The well locations (Republic, Chapman, Garcia, and West Ranch) were chosen because of their equilibrium temperatures logs made with high-accuracy, high precision temperature logging equipment (Figures 8 and 9; Wisian et al., 1996 and 1998; Blackwell and Richards, 2004b; and Negraru et al., 2008). An additional temperature log from the Pleasant Bayou well (DOE #2) was used. That well was logged in 1988 by Panex (Randolph et al., 1992).

The difference between the well log header BHT values, the Harrison corrected temperature values, and the equilibrium well measured temperature - depth curves is shown in Figures 9 a - f. The BHT data were selected within ±0.5° of latitude and longitude (~30 mile radius) around the equilibrium well location. By limiting the distance from the equilibrium well, the data are assumed to be most comparable. The equilibrium temperature graphs show that the well log header BHTs are generally too cold in comparison to the in-situ temperature. After applying the SMU-Harrison correction, the data fall more tightly around the logged equilibrium temperature line.

The West Ranch well (Figure 9d) has the poorest correlation to the corrected data. This limited correlation could be due to the influence of shallow water sources for waterflooding of the West Ranch field to push the oil out of the deeper formations. The West Ranch well was measured by the SMU Geothermal Laboratory in 1983.

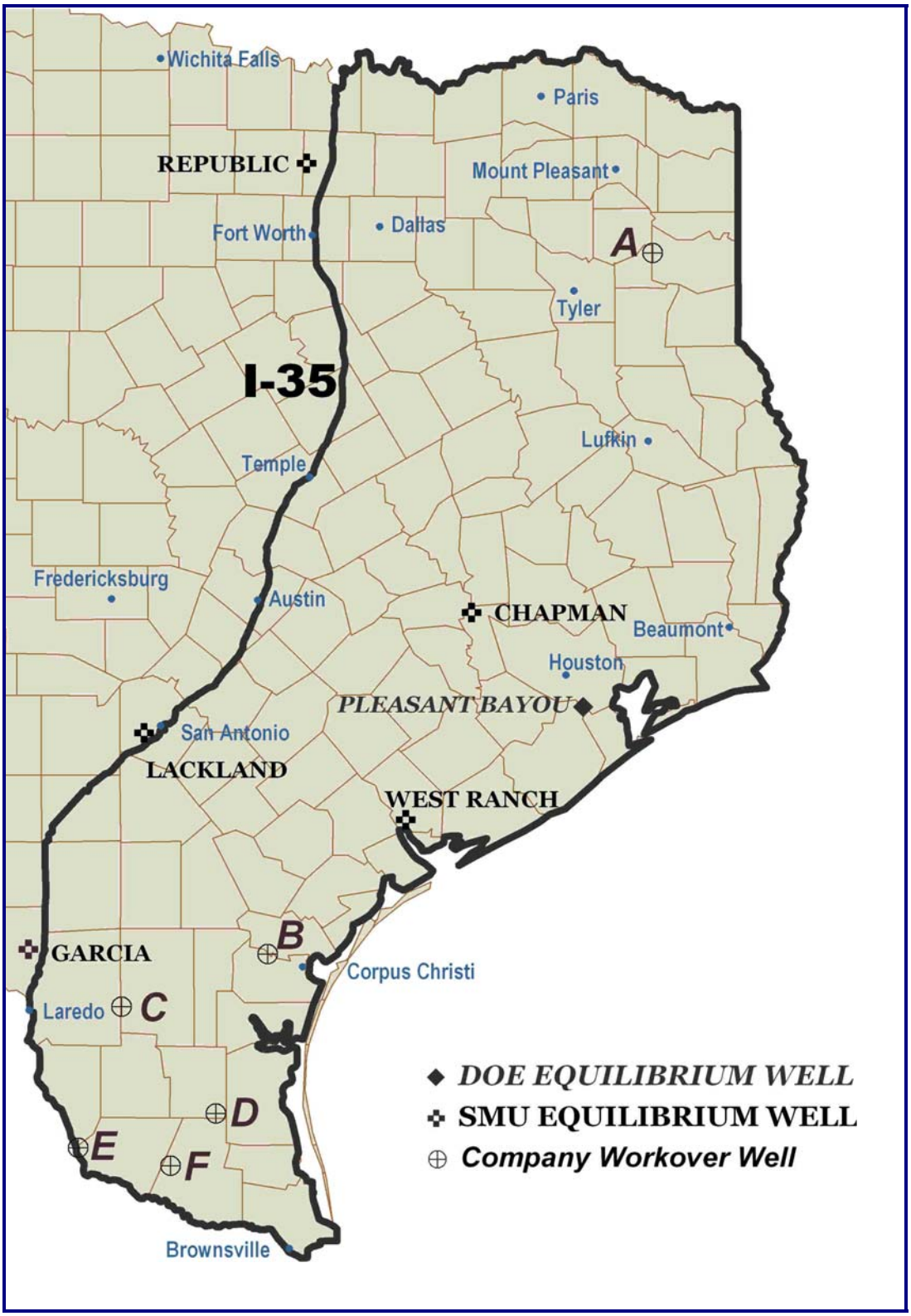


Figure 8. Locations of wells with equilibrium temperature logs used to compare temperature corrections applied to well log bottom-hole temperatures.

Figure 9 (a - e). Equilibrium temperature data are shown as a black line, the log header BHT values in the area shown as a square symbol, and the corrected BHT values are shown as a cross symbol.

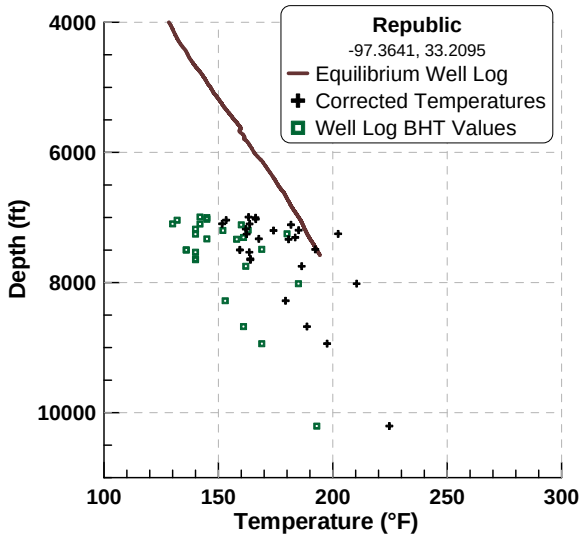


Figure 9a. Republic Well

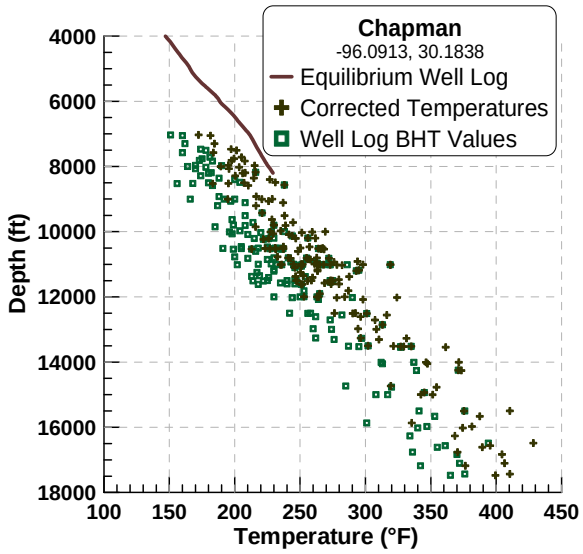


Figure 9b. Chapman Well

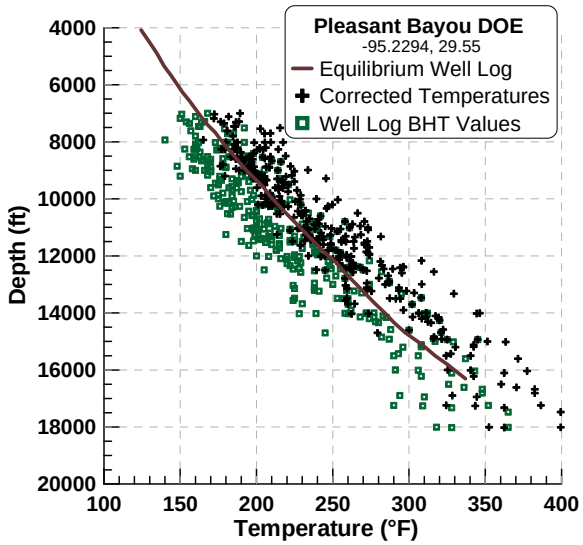


Figure 9c. Pleasant Bayou DOE Well

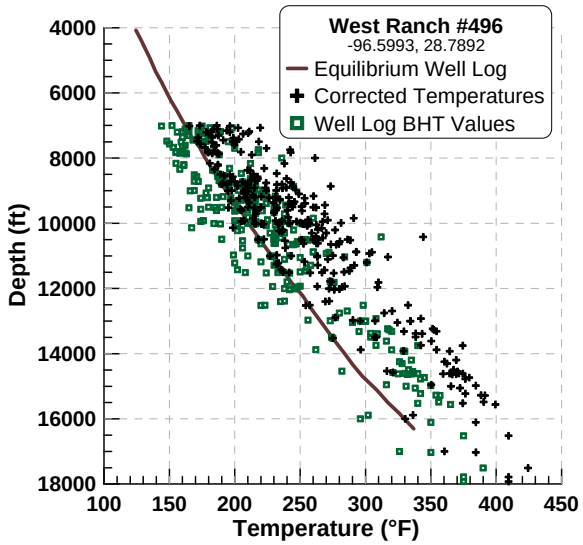


Figure 9d. West Ranch #496 Well

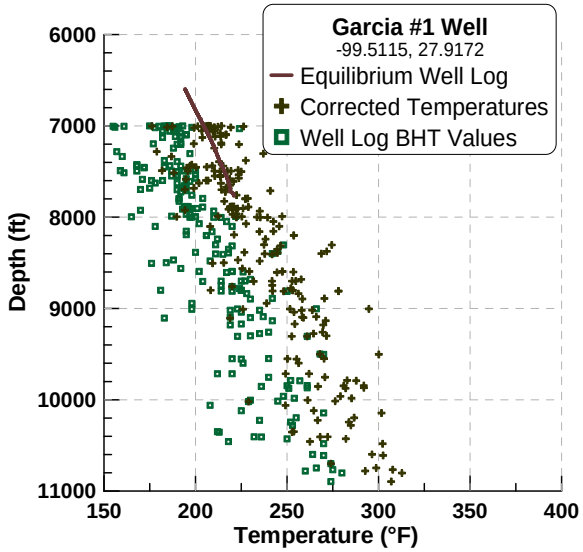
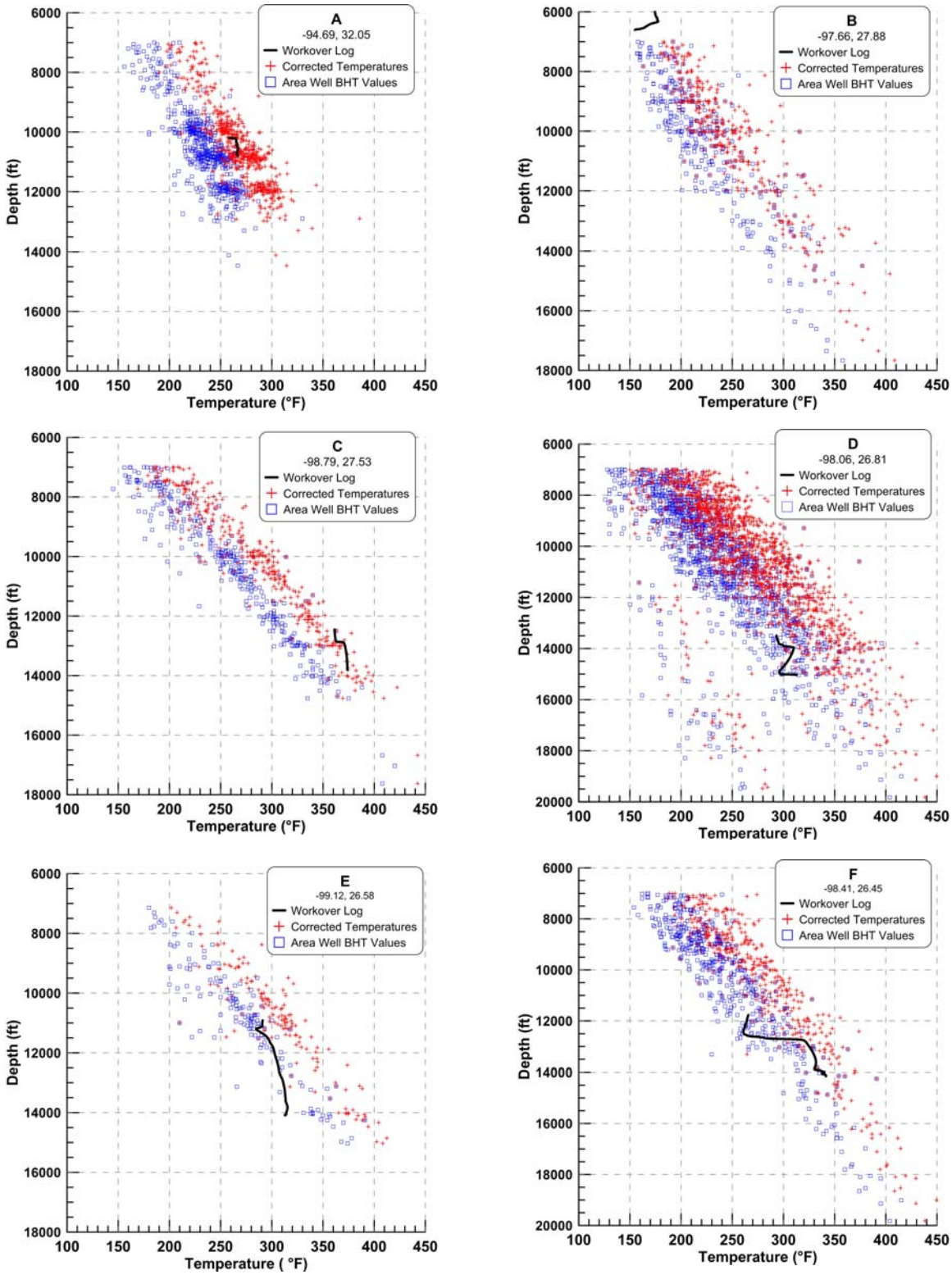


Figure 9e. Garcia #1 Well

Companies today use high accuracy temperature logs as production logs to help them understand wellbore flow conditions. New technology developments have made routine high resolution temperature measurements possible (Blackwell et al., 1998). However, this does not mean that the measurements are optimum (Blackwell et al., 1997). Measurements may be taken months to years after drilling, but not necessarily after the well has been out of production and is in thermal equilibrium. These very detailed temperature logs assist in determining where fluid (gas, oil or water) is entering the well or if fluid is flowing up/down within or behind the casing. When gas enters a well, the expansion of the gas will cause the temperature to drop rapidly as it expands because of the pressure change. If water is flowing behind the casing or laterally, then the temperature will remain fairly constant for the distance the fluid is flowing. The following examples in Figure 10 show how much temperature can change within a small depth range. The highest temperatures measured are considered closest to in-situ values (the SMU corrected temperatures) and the cooler temperatures disturbed (original BHT). Wells are not identified as the actual names are proprietary. All wells are from south Texas.

Figure 10 (a - f). The workover well temperature log is shown as a black line, uncorrected BHT values within an area of ±0.5 longitude and latitude are shown as a square, and the corrected well temperatures are shown as a cross. Locations are shown by letter on Figure 8.



The curves shown in Figure 10 are also helpful to understand the temperature profiles for the wells in the fields around each workover well. The graphs also show the variation in the temperature trends according to the geological structure as depicted by Figure 10 D where there are two geothermal trends in the area, one colder than the regional. Information about the reservoir thicknesses can be depicted by the depths plotted as shown by breaks in the data (Figure A). The temperature -depth graphs in Figure 10 show that most areas in South Texas are over 300°F, even uncorrected BHT measurements, by 14,000 ft.

Pressure Data

For the Fairway Field area, pressure data from the production well records were used as a second comparison of the application of the SMU-Harrison correction on the SMU-TX RRC data points in Anderson and Henderson counties (Figures 7 & 11). The SMU-Harrison corrected BHT data follow the general trend of the pressure data with values slightly warmer than the uncorrected (blue triangles). There is an outlier group of data at 10,000 feet that are related to a variety of disturbances and recording errors. Pressure data are an improved parameter to use for estimating in-situ values when available over well log BHTs. This is because pressure data are collected with a temperature measurement throughout the life of a well. These are not considered an exact in-situ temperature because the well is active and has usually been flowing. They do represent values not influenced by drilling fluids, so are considered close to undisturbed (Kehle et al., 1970; Erkan et al., 2007). The pressure data contain numerous values for a specific well which can then indicate a reasonable spread of temperatures at that depth. These temperatures usually vary 10 to 25°F for a similar depth measurement as shown by the sample set of wells in Figure 12.

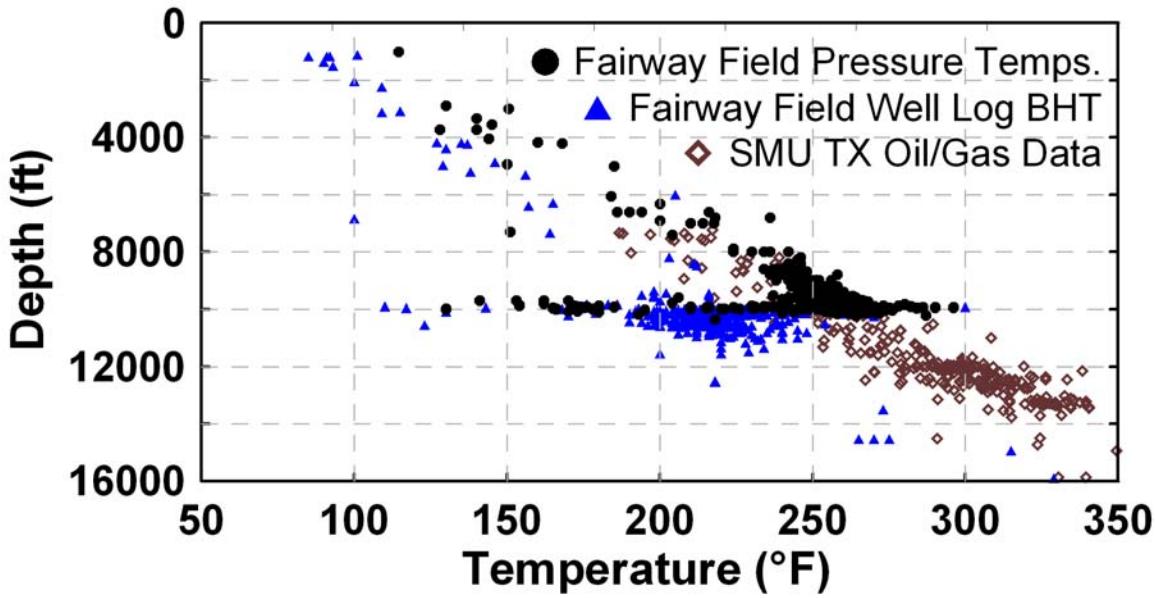


Figure11. The corrected SMU-TX RRC BHT data (diamonds) located within or near the Fairway Field, the averaged Fairway Field pressure/temperatures data (circles), and the uncorrected Fairway Field BHT data (triangles) are plotted. The trend of the pressure temperatures and corrected temperatures are similar except within the reservoir zone at approximately 10,000 feet.

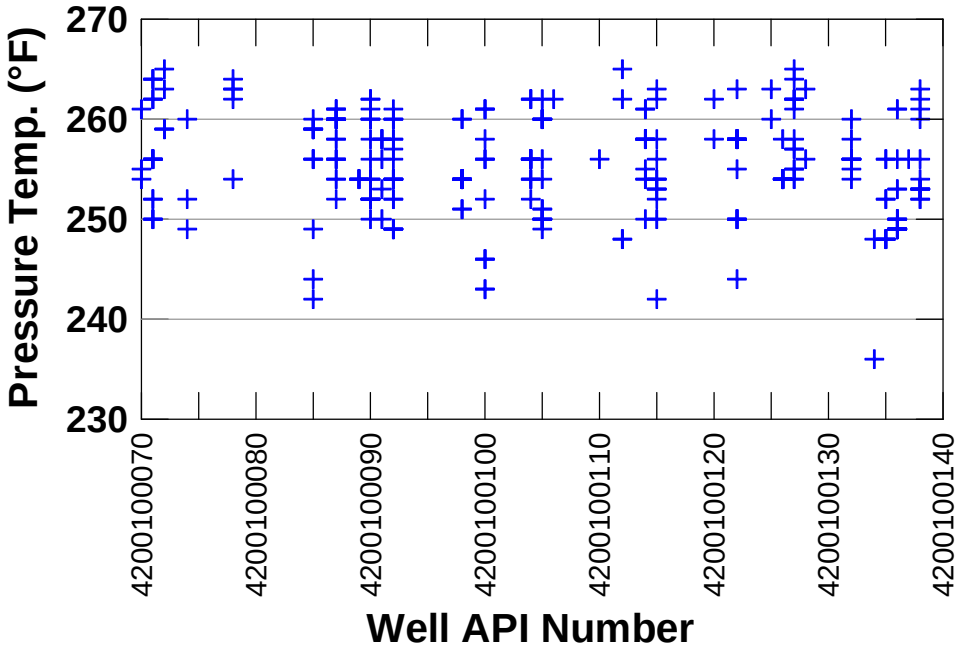


Figure 12. Hunt Oil Company Fairway Field temperatures from a subset of the pressure data. For the specific well site (API #), the amount of variation in temperature readings over time is shown. Each vertical line of data represents one well. The well API number is shown on the bottom axis with 42 = Texas and 001 = Anderson County, then the individual well numbers.

ANALYSIS OF THE DATA

The data from the SMU-TX RRC database, the AAPG Geothermal Well Survey (AAPG, 1994), Gulf Coast Geopressure database (Gregory et al., 1980), Freestone County (Burns, 2004), and Fairway Field (Hunt Oil Company and Kweik, this report) were used to generate a series of temperature maps of the area of the study at various depths and at different scales. The maps were produced using software which developed a 3-dimensional lattice and second program for 2-dimensional grids. The 3-dimensional lattice is able to take into consideration the gradients of data in all directions to create smooth contour maps of temperatures at specific depths. These maps represent the general trend of the data and regional temperatures. Depths are slices of the lattice for a specific interval (Figure 13 a to h) shown at 1,000 feet intervals between the depths of 7,000 to 14,000 feet. The highest values are in the South Texas Wilcox formation zone (Counties: Zapata, Jim Hoggs, Webb, Duval, Live Oak, McMullen, etc.). The coldest area in this assessment was in the North Central portion of the state with Cooke and Grayson Counties having the lowest temperatures. The reason for this area being colder than other parts of eastern Texas is related to the basement rocks associated with the Wichita Mountains and the rift zone associated with them (Muehlberger et al., 1967).

Next the data were used to generate a 2-dimensonal set of maps at 9,000 and 12,000 feet focused on the county level (Figure 14 a - b). Wells with depth values of ± 2,000 feet from the mapped depth were selected. The well gradient was used with the corrected temperature to interpolate to specific depths of 9,000 and/or 12,000 feet and then contoured to create temperature maps. The well locations are plotted showing where data were used for generating the maps to assist viewers in determining the accuracy of map values and data variability. At this level of detail, the individual counties can be viewed with the location of data points clearly shown. Although there are areas containing counties with little to no data, it is helpful to see where the county sits within the larger temperature trends for the region. Most of the wells are relatively densely located, with the average distance between wells approximately 3.6 miles. From this the map contours are based on a grid spacing of 13 square miles.

The depths of 9,000 and 12,000 feet were chosen for the 2-dimensional detailed maps because 9,000 feet is the initial depth where most of Eastern Texas is near 200°F. This is the initial temperature needed in Texas, with the current binary turbine technology requirements. Temperatures at 12,000 feet were chosen because in this area the majority of “deep” oil and gas

wells are completed between 12,000 and 13,000 feet (Figure 15). Wells in this depth range are representative of what is currently available to use as an exploration tool for the development of geothermal power.

Figure 13 (a - h). Slices of a 3-dimensional lattice for depths of 7,000 to 14,000 feet showing generalized trends of the temperature at each depth from a low of 125°F to over 360°F.

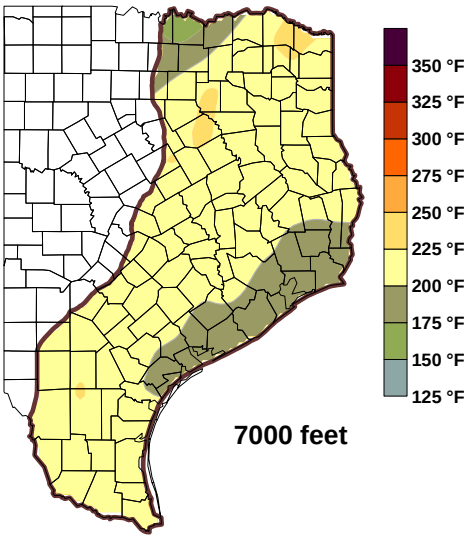


Figure 13 a. 7,000 feet depth temperatures

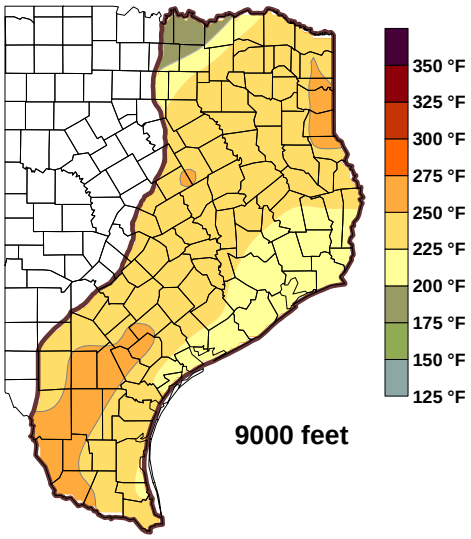


Figure 13 c. 9,000 feet depth temperatures

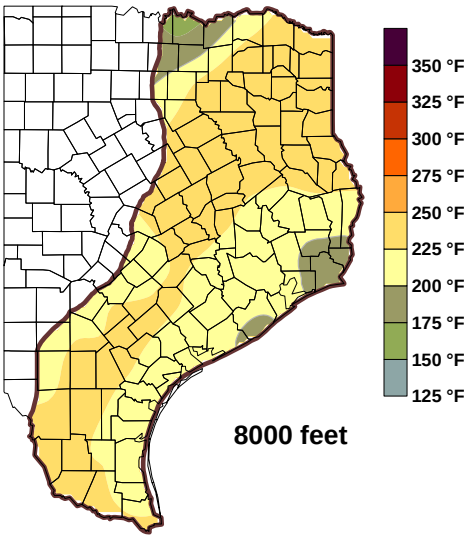


Figure 13 b. 8,000 feet depth temperatures

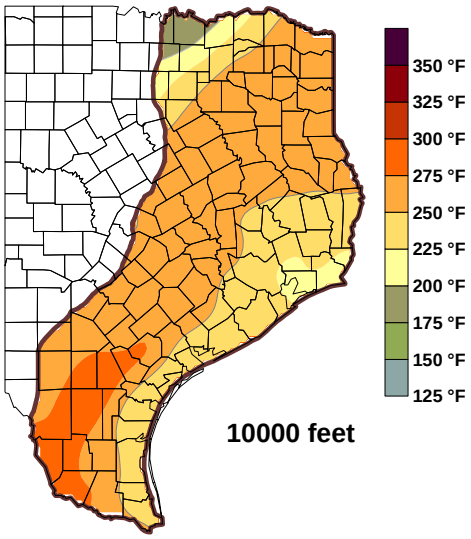


Figure 13 d. 10,000 feet depth temperatures

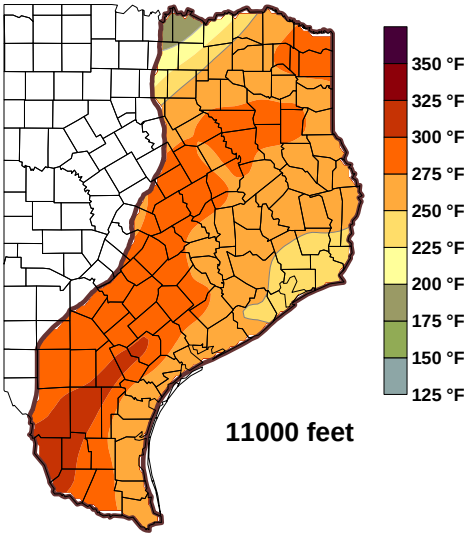


Figure 13 e. 11,000 feet depth temperatures

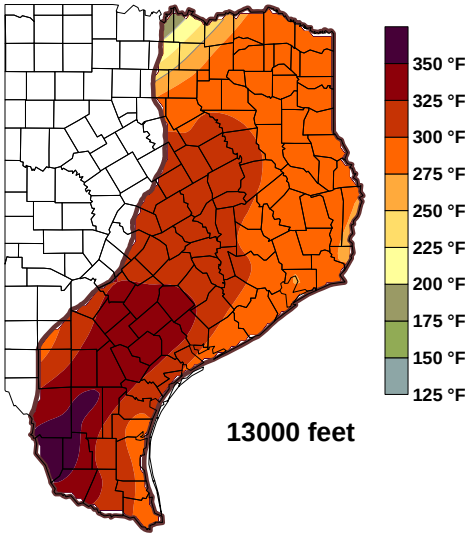


Figure 13 g. 13,000 feet depth temperatures

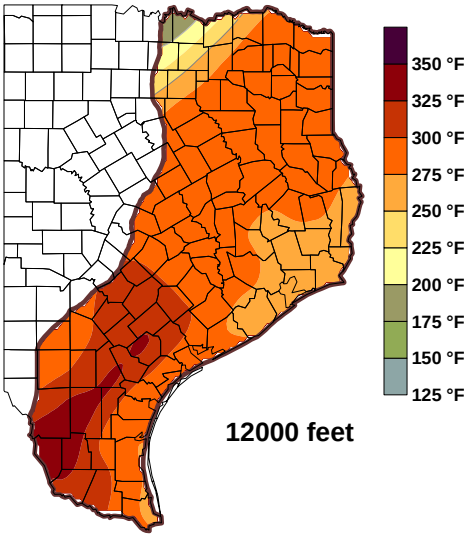


Figure 13 f. 12,000 feet depth temperatures

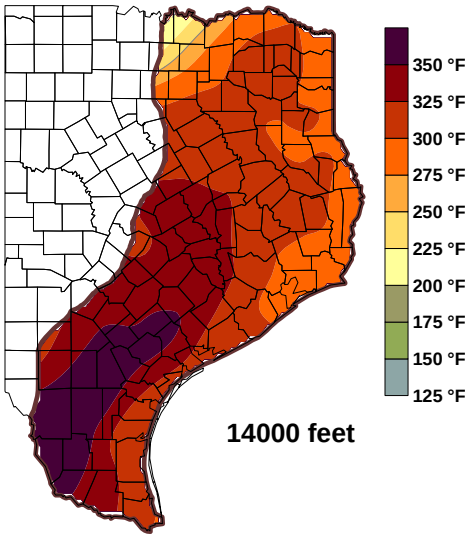


Figure 13 h. 14,000 feet depth temperatures

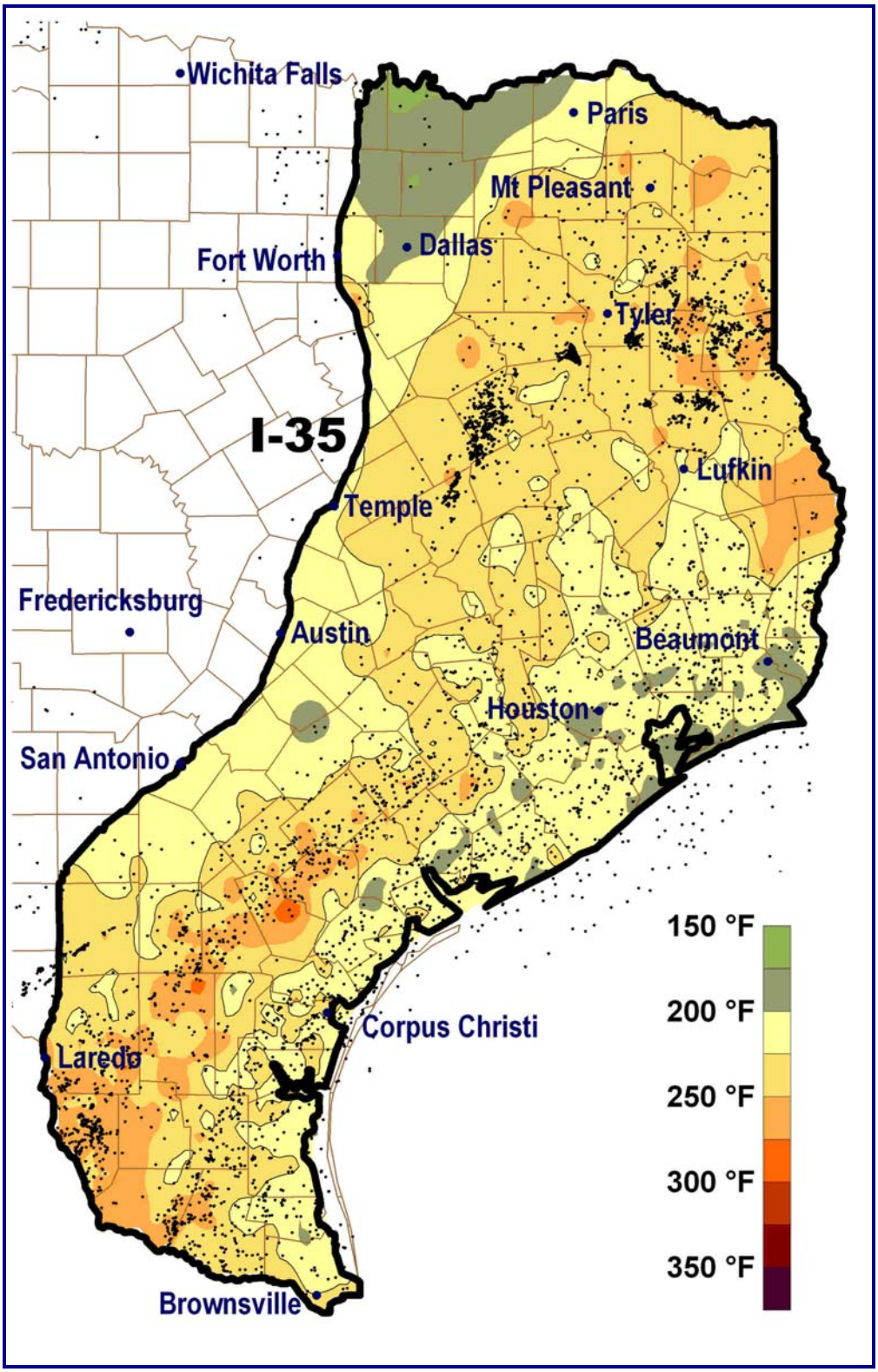


Figure 14a. Map of detailed corrected temperatures at 9,000 feet. Data are shown as small dots.

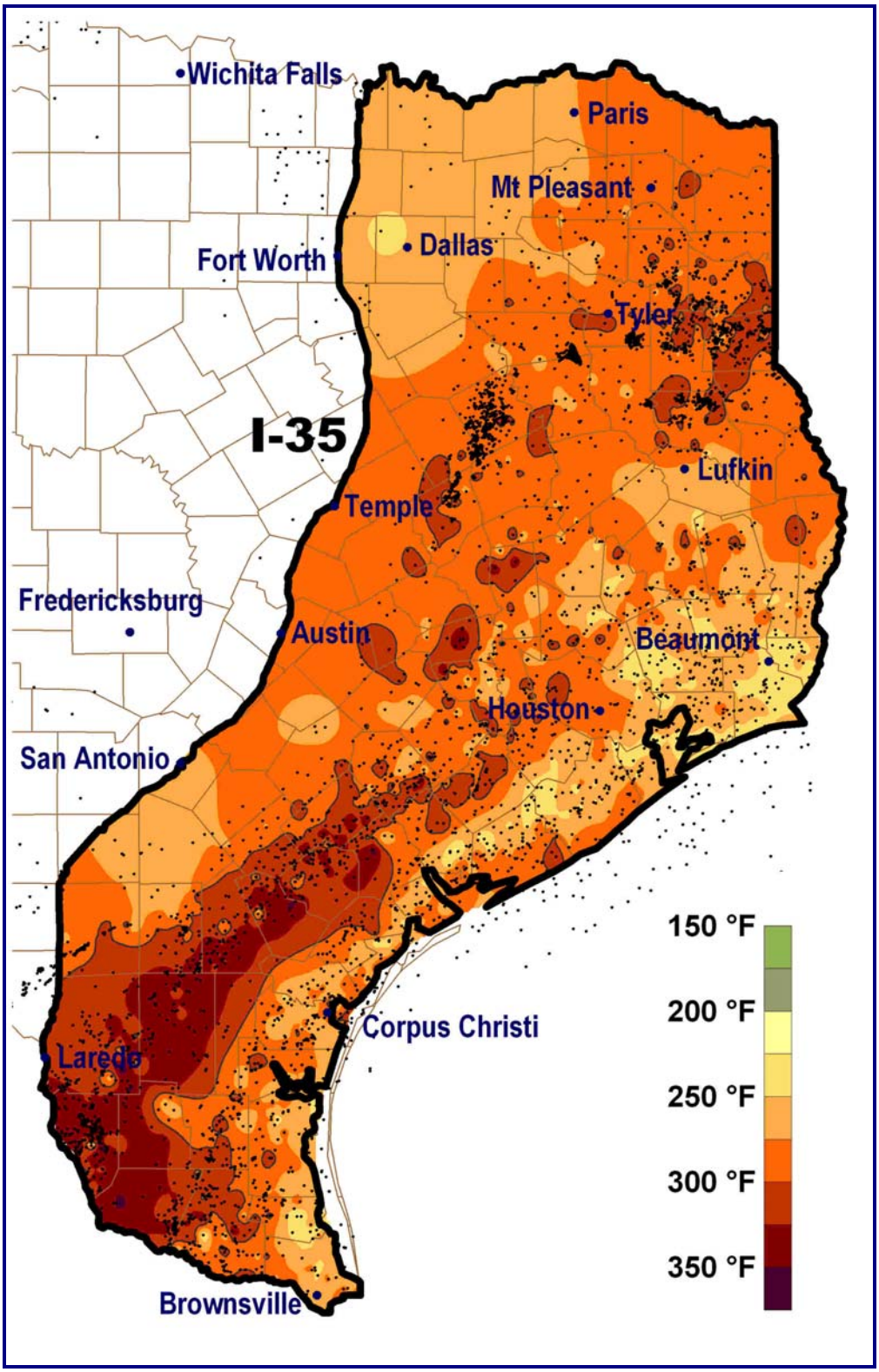


Figure 14b. Map of detailed corrected temperatures at 12,000 feet. Data are shown as small dots.

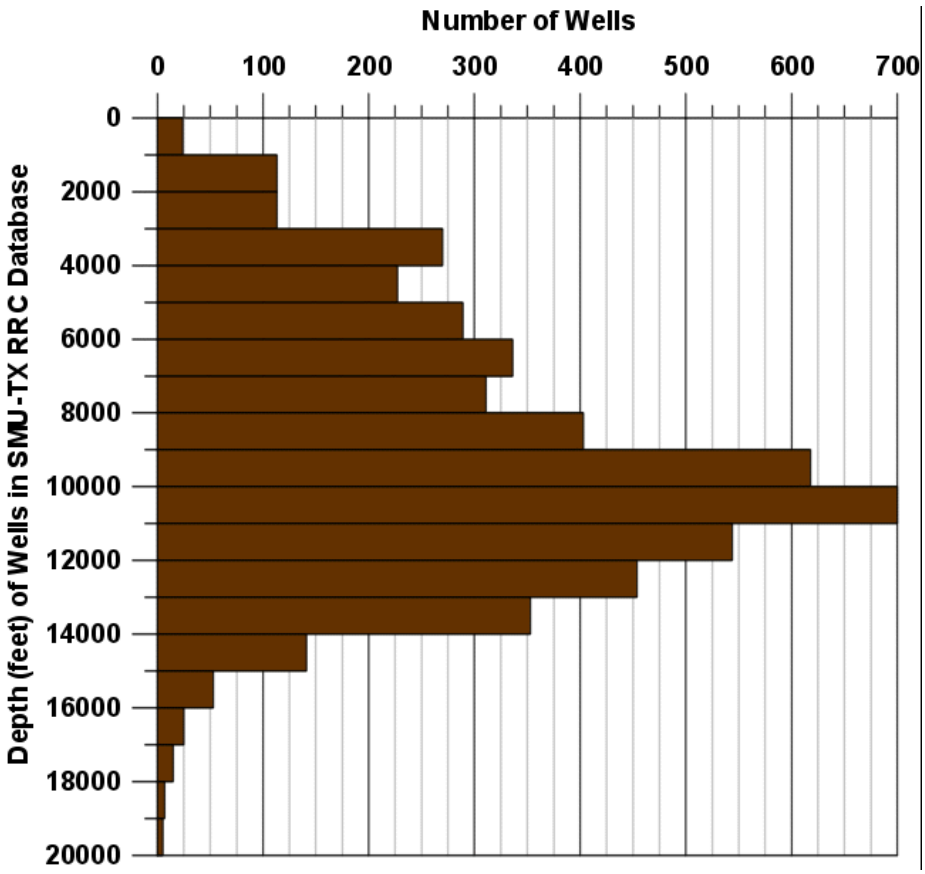


Figure 15. Histogram of drilling depth versus number of wells for the study area.

In reviewing the detailed temperature maps at smaller subsets such as field-size, the temperatures can vary by up to 25°F at a given depth as shown by the Fairway Field data. The reason for this difference is related to the specific conditions existing at the time the temperature was measured. There are numerous situations that cause temperature values to vary that cannot be captured with the limited well condition information available and the relatively simple applied corrections used here.

1. The oil and gas data BHTs are collected at the time of logging by using a maximum reading thermometer, yet the logging gear may be lowered deeper than the recorded depth generating too warm a temperature value.

2. Another logged well temperature value may have been recorded by the logging company, instead of the recorded measurement at the time of logging.

3. The surface temperature variation from summer to winter (and in some instances day to day) impacts the well temperature by changing the drilling fluid temperature. Temperatures are further altered by the duration of circulated drilling fluid and drilling conditions.

4. The length of time the well sits between the last circulation of the drilling fluid and the logging of the well impacts the temperature. The logging typically occurs within 6 to 10 hours, but for some wells it is months since drilling so the well starts to return to the undisturbed value.

5. Geologic structure will affect temperatures because of fluid movement along pathways and faults through a stratigraphic zone.

The corrected temperature data show that by 9,000 feet, the majority of Texas east of the Interstate I-35 corridor is at or above 200°F (Figure 14a). The two primary areas with a concentration of temperatures less than 200°F are the North Texas region where values are in the 150-175°F range, and the band along the Gulf Coast with temperatures of 175°F to over 200°F. The hottest areas at 9,000 feet are located in East and South Texas with temperatures reaching 250°F to over 275°F respectively.

The corrected temperature data for 12,000 feet have a pattern similar to the 9,000 feet depth level. At 12,000 feet, throughout the entire area, temperatures reach at least 200°F, but more often are at or above 250°F. The hottest areas continue to be East and South Texas with temperatures commonly over 300°F, some measuring as high as 350°F at 12,000 feet.

Temperature values continue to increase with depth such that at 13,500 feet the corrected temperatures are consistently over 300°F throughout the majority of the project area (Table 2; Figure 16). At 14,500 feet the average corrected temperature value is 340°F. Wells drilled to depths over 15,000 feet are restricted primarily to regions of the Gulf Coast and South Texas because of the sediments are thickest in these areas. Here the average corrected temperature continues to increase to 350°F at 17,500 ft. In the data for this assessment, the deepest well drilled since 2000 is in South Texas along the Gulf Coast is in Brooks County, reaching a depth of 19,829 feet with a corrected temperature of 438°F. The hottest wells are in Hidalgo County, South Texas (450°F at 19,006 feet) and in Lavaca County, west of Houston (452°F at 19,456 feet)

Table 2. Interval depth with average and maximum temperatures for that 1,000 feet interval.

Depth Range Feet	Number of Wells	Average Uncorrected Temperature °F	Average Corrected Temperature °F	Maximum Corrected Temperature °F
12,000 - 13,000	879	263	299	363
13,000 - 14,000	628	283	320	430
14,000 - 15,000	330	304	340	423
15,000 - 16,000	159	306	349	420
16,000 - 17,000	107	319	361	422
17,000 - 18,000	60	319	358	454
18,000 - 24,000	46	362	402	544

The deeper (>13,000 feet) temperatures in East Texas were calculated by Negraru et al, (2008) using heat flow values and rock thermal conductivity. These are determined to be hotter than the wells in South Texas and the Gulf Coastal areas. The wells in this assessment for East Texas are generally less than 13,000 feet, thus in Figure 14b, the East Texas temperatures are generally extrapolated rather than measured for the depths over 12,000 feet. Wells are not drilled deeper in this area due to the basement rock of the Sabine Uplift being relatively shallow (Figure 5). These basement rocks of the Sabine Uplift apparently have high contents of natural radioactive elements that cause the higher than normal heat flow in this area (Negraru et al., 2008). It is due to this additional heat generation that at 9,000 feet, East Texas temperatures are warmer than those in North Texas on the other side of the Ouachita Overthrust Belt.

The purpose of the detailed maps in Figure 14 is to direct initial exploration studies, and not for specific site selection. Formation temperature is one of the variables used when selecting wells to focus on for geothermal energy development. The corrected temperature is a starting point for the power production calculations (Appendix C). From this temperature the fluid will slightly cool as it flows to the surface and moves though the pipe at the well head to the turbine. The temperature decrease is a function of distance, fluid speed, and pipe insulation. If the fluid from the well is a combination of oil, gas, and brine, then depending upon the power plant design and technology, there may need to be separation of fluids before electrical generation. This process would further decrease the fluid temperature.

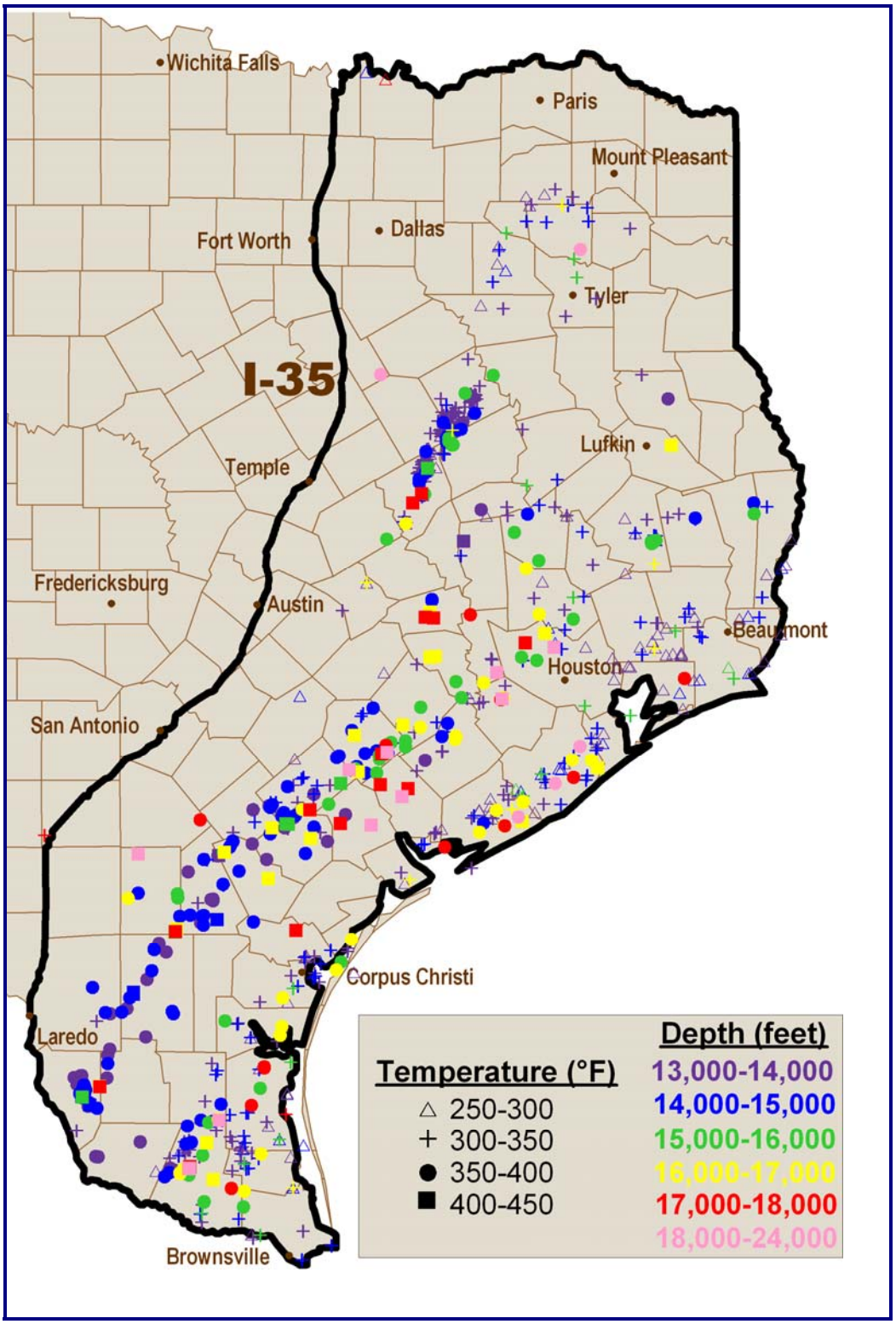


Figure 16. Well locations with depth between 13,000 to 24,000 feet. The color of the symbol represents the depth and the symbol shape represents the temperature range.

FAIRWAY FIELD

During the summer of 2008, the Hunt Oil Company provided well logs, production, and pressure data (measurements taken over the life of the wells) from the Fairway field for the SMU Geothermal Laboratory to use for a study of long term changes in pressure and temperature in an operating the oil and gas field (Hunt Oil and Kweik, this report). A total of 2733 well logs were reviewed. The information collected included: latitude/longitude, well depth, elevation, BHT, TSC, gradient, date of drilling, and type of log. The well head surface temperatures were measured during a site visit in August 2008 using a heat gun to compare the BHT measurement with current well head fluid temperatures.

Fairway Field (James Lime Unit) is an oil field located in Poynor, Texas covering approximately 23,000 acres in Anderson and Henderson Counties (Figure 17). The field is operated, but not wholly owned, by Hunt Oil Company. Discovered in 1960, it was estimated to have over 410 million barrels of oil. Since its first production in 1960, Fairway field is still producing. The field currently includes 147 wells: 83 oil producing wells, 37 gas producing wells, 8 brine disposal wells, and 19 shut-in wells. The total cumulative production as of December 2008 was 213 million barrels of oil, 1 BCF of gas, and 477 million barrels of water. Water and gas injection have been used to stimulate hydrocarbon recovery at different times and locations. Currently, the water cut is 94% of the total production, while approximately half of the original in place oil remains in the field.

Data results from the well injection and cement logs were available for this assessment, but not used. Injection well logs are not reliable, in that they will almost always measure colder than the actual formation and will vary depending on the amount and rate of fluid being pumped into them. Temperatures from cement logs have values hotter than normal, due to the chemical reaction taking place in the cement between the well and casing, releasing excess heat to the surroundings.

The field has undergone four major stages in its 50 years of production history. The first stage involved the primary recovery of oil at a high rate for two years. In its second stage, the recovery scheme was based on water-alternating-gas (WAG) miscible recovery flood in 1963. This involved the injection of a large volume of water and gas to facilitate migration of oil towards the well bores to improve production. In the third stage, the field was put through a tertiary recovery

scheme, where a large volume of natural gas was injected into the field to help recover even more oil (Figure 18). However, this injection was halted in 2000, due to the rise in natural gas prices. The gas was then recovered. The production of the stored natural gas eliminated the need for water injection. In 2000, Fairway entered its current stage, which includes dehydrating the field under a pressure depletion drive to induce a gas blowdown phase with high water flow (David Luttner, personal communication).

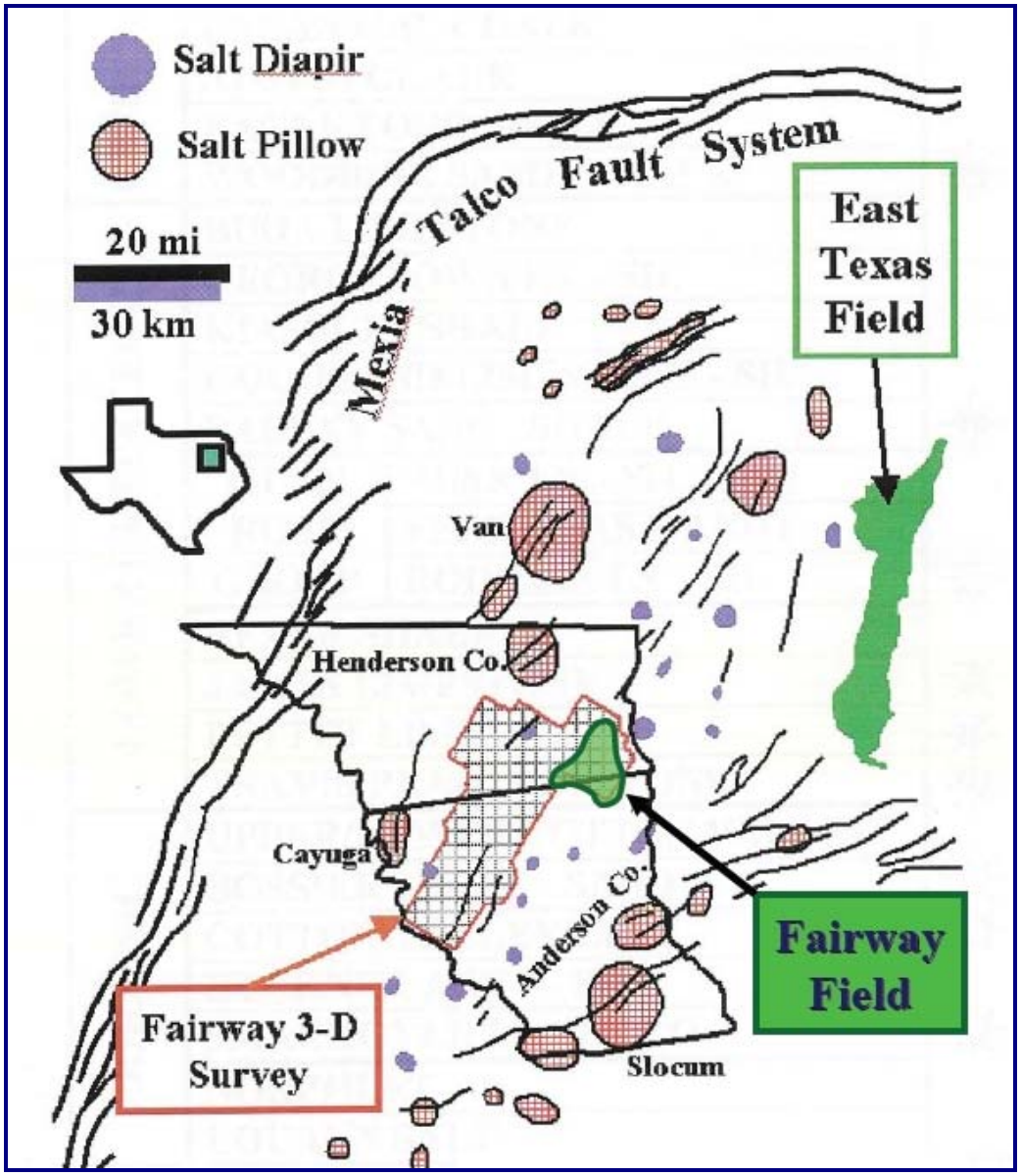


Figure 17. Overview map of the location of Fairway Field in East Texas, Henderson and Anderson Counties, the base is from Seni and Jackson (1983)

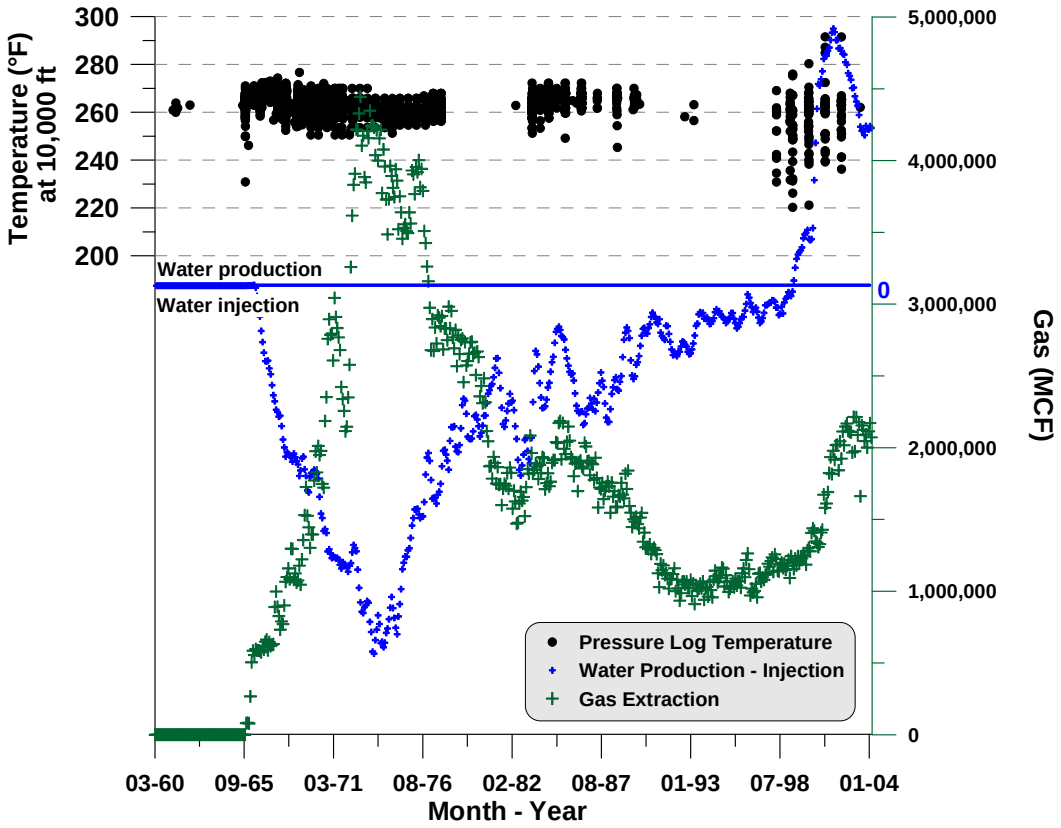


Figure 18. Fairway Field pressure log temperatures compared to the water injection and gas extraction from March, 1960 to January, 2004. There is no axis for water, rather distance below the blue line shows increasing injection and distance above the blue line shows increasing production.

The review of temperature changes over the field production history showed only slight fluctuations in temperature from the initial measured values in 1960 to 2005. The well log BHT temperature values were from a subset of logs between 9,000 and 11,000 feet and corrected to 10,000 feet using the average geothermal gradients based on a surface temperature of 70°F (Figure 18). There were 2070 pressure logs used to review the temperature changes. The average temperature value fluctuates slightly between 1960 and 2004, most directly related to the amount of water injected (waterflooding) and the gas extraction, yet it is difficult to determine if one activity has a greater impact on the reservoir temperature than the other with the two activities occurring at the same time. The average temperature decreased from 1965 to 1976. Then after the waterflooding and gas extraction were reduced, there is a slight increase in measured temperatures in the 1980s indicating the field did start to return to the warmer, natural background temperature. There is more scatter in the data in the 2000s that possibly is related to the water production, or the increase in the number of wells. The water amount shown in Figure 18 is the difference between the monthly injection and production values. Throughout the life of the field as noted above, there has been injection and extraction of both water and gas.

GEOTHERMAL RESOURCE UTILIZATION

This eastern Texas geothermal assessment focused on the moderate to high temperature geothermal resources accessible through depths typically associated with hydrocarbon wells. The advantages of using oil and gas wells/fields are: 1) the geothermal and oil and gas industries have overlapping knowledge bases that can build on each other's expertise to improve both industries; 2) existing oil field data are accessible for initial reservoir review and understanding, reducing exploration costs compared to conventional geothermal systems; 3) oil and gas fields have the existing infrastructure necessary for geothermal project development, i.e., roads, well pads, electrical connections to the grid, etc.; 4) the new binary turbine designs for distributed energy production makes them easier to plug and play with oil/gas wells; 5) oil and gas fields are normally in a state of flux with wells coming online and being abandoned creating new opportunities for geothermal production. There are different scenarios which can be used to develop the geothermal resources that exist in Texas from electrical production to direct use of the heat. These are explained in this next section.

Electrical Production

For geothermal resources to be commercially viable, heat must be removed from the produced fluid at a sustainable rate, and return a reasonable profit. These conditions depend on the quality of the resource - temperature, depth, fluid characteristics, and the ability to extract and then reinject the fluids. These factors are a function of geology, i.e., rock type, layer thickness, porosity, permeability, pressure, and thermal history. Determining the temperatures within a geothermal reservoir (field) is the first step in evaluating the resource since temperature can be used to determine the extent of stored energy (Appendix C). Using the temperature, estimates are made as to how much heat is available for producing electricity under different fluid production scenarios. Secondly, a recovery factor is calculated for the amount of heat available for extraction. The recovery factor depends on such variables as the type of fluid (water or gas) that causes flow from the formation into the well, rock and fluid compressibility, the water influx from shale, reservoir pressure decline, production rate, amount of heat extraction at the surface, and which formation is used for fluid injection. Many of these variables are difficult to evaluate and typically a well production and injection test are needed.

Since Texas has extensive and diverse geothermal resources for electrical production, it is helpful to divide them into three categories for discussion: 1) geothermal-geopressured resources; 2) coproduced fluids; and 3) enhanced geothermal systems.

Geothermal-Geopressured Resources

A geothermal-geopressured resource consists of highly pressurized hot brine, due to pore water being trapped during the rapid burial history. There are three dominate parallel zones of geopressured formations (Wilcox, Vicksburg, and Frio) consisting of thick sand deposits that parallel the Texas Gulf coastline. These bands are considered the most important resource of geopressure in the United States (Wallace et al., 1979) (Figures 4 and 20). The weight of the impervious rock layer above the entrapped sand lenses, coupled with decomposition of existing organic matter, results in highly pressurized zones containing dissolved methane. The heat in the fluid is from the sediment being heated from below by natural radioactive decay in the basement rock. Wells drilled into geopressured formations flow naturally to the surface. Water temperatures in these formations range from approximately 200°F to over 450°F. The total geopressure thickness is estimated at 50,000 feet; wells are drilled into geopressure at depths of 8,500 to 18,000 feet in eastern Texas (SMU-TX RRC data).

Although the entire Gulf Coast area is considered geothermal-geopressured at various depths, Bebout et al., (1982; 1983) described specific "geothermal fairways" having the most prospective reservoirs. These fairways are based on pressure, temperature, and sediment thickness. From northwest to southeast the fairways are in the *Wilcox formation*: Zapata, Duval, Live Oak, DeWitt, Colorado and Harris; and in the *Frio formation*: Hidalgo, Armstrong, Corpus Christi, Matagorda, and Brazoria (Figure 20). Examples of the geothermal fairway parameters for the Wilcox formation are shown in Table 3.

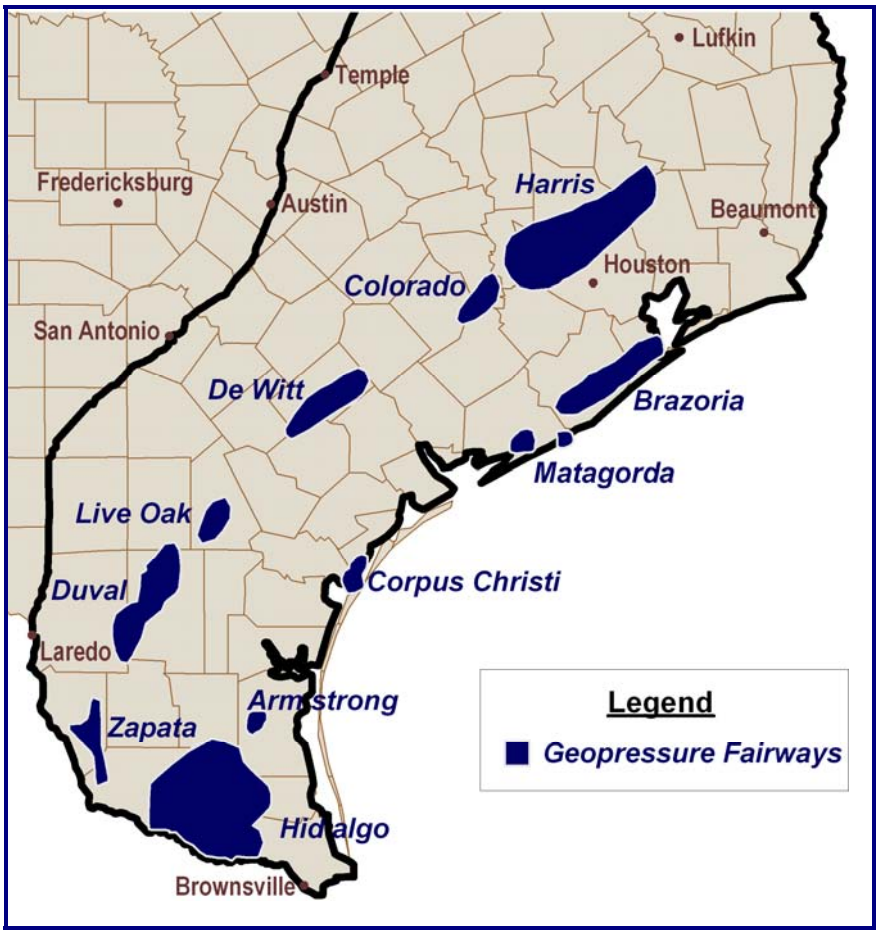


Figure 20. Geothermal - geopressured fairways as depicted by Bebout et al. (1982; 1983).

Table 3. Summary of the physical characteristics of the six Wilcox geopressured geothermal fairways (Table 4, Bebout et al., 1982). * SWC = Side wall core; ** DC = Diamond core

	ZAPATA	DUVAL	LIVE OAK	DE WITT	COLORADO	HARRIS
PART OF WILCOX	Upper	Upper	Upper	Lower	Lower	Lower
DEPTH TO TOP OF PROSPECTIVE SANDSTONE (ft)	9,600 to 10,500	11,000 to 12,000	9,200 to 11,000	10,490 to 10,660	10,960 to 11,400	12,500 to 13,300
THICKNESS OF PROSPECTIVE SANDSTONE (ft)	280 to 620	> 600	> 600	550	1,600	> 2,000
TOP OF GEOPRESSURE (0.7 psi/ft)	10,700 ft	10,000 ft	9,950 ft	10,000 ft	12,000 ft	11,550 ft
TEMPERATURE	300° F at 11,400 ft	300° F at 10,750 ft	300° F at 11,000 ft	300° F at 10,850 ft	300° F at 11,780 ft	300° F at 12,990 ft
POROSITY (%)	17 to 22	7 to 14	16 to 24	6 to 25	4 to 19	Average: 15
PERMEABILITY (in millidarcys)	0 to 19 *SWC	0.1 to 44 **DC	5 to 40 SWC + DC	0.01 to 242 DC	Most < 5; locally up to 545 DC	Most < 1 DC

Wallace et al., (1979) estimated that over 2,000 exajoules (EJ) of recoverable thermal energy and methane are contained within the Texas Gulf Coast geopressured deposits. Uncertainties about the reservoir mechanics, the connectedness of the geopressured zones, and their capability to produce brine for extended periods of time, are often brought up as a concern. In the final summary documentation of the extensive DOE studies, John et al. (1998) state the brine flow tests completed on the wells at Pleasant Bayou (Brazoria fairway), Gladys McCall (Cameron Parish, LA), and Hulin (Vermillion Parish, LA) proved the geopressured resource along the Gulf Coast to be viable for development (Figure 21). The longest tests were done on the Department of Energy (DOE) Pleasant Bayou well No. 2 in Brazoria County. During 1989-1990 electrical production demonstration the well (perforated from 14,644 to 14,700 feet) produced 10,000 bbls/day of brine at 290°F along with 22 scf/bbl of gas. The total cumulative flow for the well from 1978 to 1992 was 25 million bbls with the average flow rate during the last five years at 18,000 bbls/day at a pressure of 3,000 psi (John et al., 1998). From this demonstration, it was concluded that the well could produce at 20,000 bbls/day for 20 years (Shook, 1992). The research also found that if a substantial portion of the produced water is reinjected into the producing reservoir to maintain reservoir pressure and fluid flow rates, more than 90 % of the gas can be extracted from the formation (Gregory, 1977). This gas extraction is accomplished while electricity is being produced from the extracted geothermal heat.

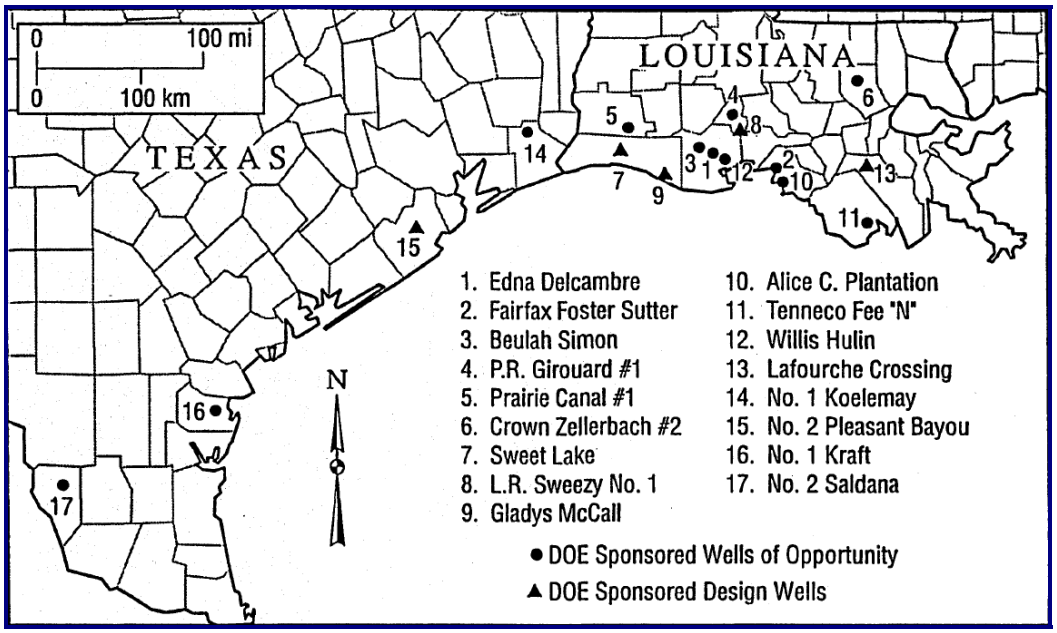


Figure 21. Location of wells investigated for the DOE geopressured - geothermal research program in the Gulf Coast (John et al., 1998).

Coproduced Resources

Coproduced geothermal resources are directly integrated into the production of oil and gas. Coproduction uses a well for the purpose of *both* the extraction of oil and/or gas and the heat from the fluids for electricity. The electricity can be used on-site or sold to the grid. Traditionally the fluid (brine) is trucked off or directly reinjected at an expense to the project. Locations where the fluids are directly injected on-site are the "low-hanging-fruit" for coproduction sites. The business plan incorporates the brine water as an economic commodity to allow for longer hydrocarbon production from a well. This type of development is the best case scenario for the utilization of the geothermal resource from an oil and gas field because of the minimal additional expense - primarily the installation of binary turbines. Fields which currently use waterflooding to increase hydrocarbon production from deep formations could be an initial focus point for geothermal development.

The second scenario for coproduction is the end of the life of oil and/or gas wells or "stripper' wells. In these cases the well produces adequate hydrocarbon volumes to be economically viable until at some point of increasing production of brine water it is no longer economic. Rather than abandoning the well, to keep it economical the well could be converted to coproduction to recover the additional expense of the produced brine. This conversion allows a greater percentage of the hydrocarbons from the field to be extracted while producing a renewable energy to run field applications and/or to sell to the grid. For the transition from an oil/gas well to a coproduced well, additional treatment of the well may be necessary since the quantity of fluid needed for geothermal electrical production is often much greater than the capping/abandonment point for oil/gas wells.

The third scenario is to work with oil and gas companies drilling new wells. When a well is drilled that produces too much water to develop as an economic hydrocarbon well, the well would be immediately completed as a geothermal well to maximize water production and the electrical power capability.

Additionally, as oil and gas fields are developed, drilling is designed to avoid all formations with water and to perforate only the zones with hydrocarbons. Because of this pattern, the geothermal resources (brine water) are left behind, "stranded" (Erdlac, 2008). The extent of stranded water in Texas fields is not readily determined because companies do not focus on those zones and records of possible water production are not required by the Texas Railroad Commission. The current

quantification of brine available is primarily a result of the research completed during the 1970s to 1990s geopressured - geothermal studies for the Gulf Coast Region. Areas such as East Texas where the technique of waterflooding is used to extract more oil and gas have current information on fluid injection volumes. Thus, it is certain that far more fluids presently exist stranded in oil and gas fields than the current records show.

Fluids Produced and Injected

Texas is the nation's number one oil and gas producer with more than 216,000 active oil and gas wells statewide. Along with these are the injection and disposal wells which return the produced water and frac fluids from these oil and gas wells. Texas has more than 50,000 permitted oil and gas injection and disposal wells[7]. Disposal wells inject fluid into an underground interval that is not producing oil and gas. Injection wells reinject fluids into the same or similar reservoir, from which the fluids originated, usually for secondary recovery of the oil. Operators use secondary recovery techniques when an oil field's recovery rate has decreased. One technique of secondary recovery, sometimes known as waterflooding, injects produced saltwater into a reservoir to reestablish sufficient pressure that will allow an operator to recover additional amounts of oil.

The quantity of water an individual oil and gas well produces is not recorded by the Railroad Commission. However, there is a section on the TX RRC W10 Form for "Daily Water" and some operators fill it in. Review of the records between 1994 and 2007 from this form includes over 12,000 wells for Districts 1 - 6 (Figure 22). Using the 12,000 wells as indicators of production depths with the most available water, there are two peaks, one between 5,000 to 7,000 feet and a second between 9,000 to 11,000 feet (Figure 23). Based on the total water produced, highest flow rates are produced at depths less than 7,000 feet and most likely have too low a temperature for electrical production (Figure 23). Of the 12,000 wells there are only three wells [API # 4223902390 (Jackson Co.), 4249900386 (Brazoria Co.), 4203931304 (Wood Co.); Figure 24] with recorded daily water production values of over 6,000 barrels per day (175 gpm) which is close to the minimum flow rate necessary for electrical production with current binary technology (~200 gpm @ 200°F for 50 kW). Combining the fluids from multiple wells is one method to achieve the desired flow rates.

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[7] Jan. 2010, http://www.rrc.state.tx.us/about/faqs/saltwaterwells.php

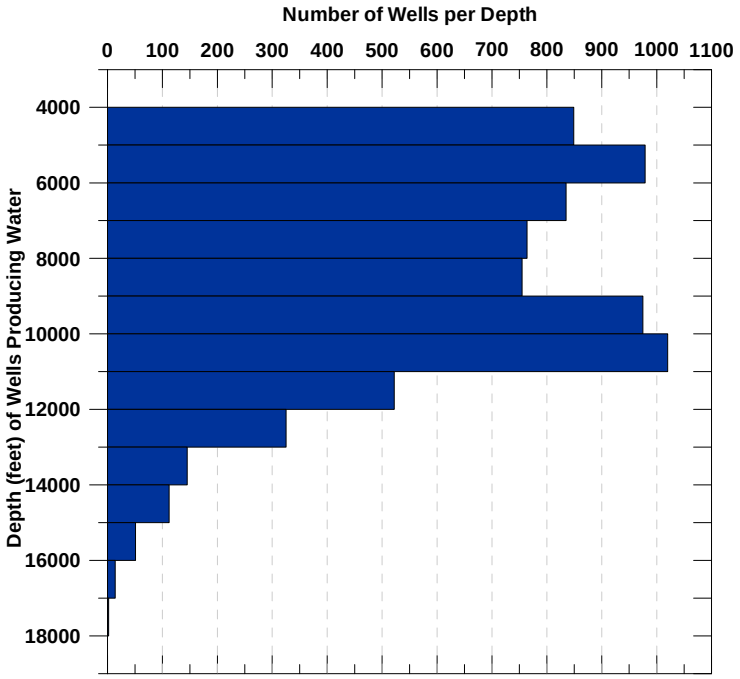

Figure 22. Histogram of recorded well daily water production (TX RCC form W10) for Districts 1 - 6.

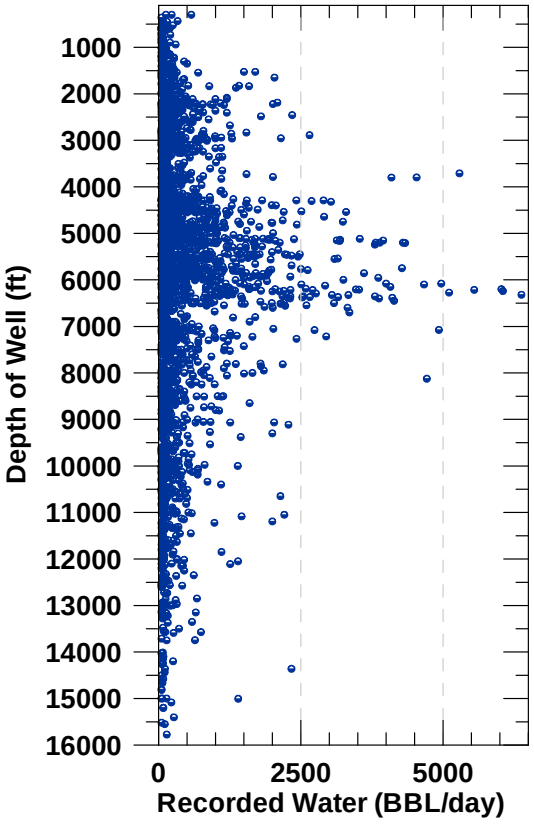

Figure 23. Daily water production versus depth of well.

The counties with the highest total volumes of combined injection and disposal are shown in Table 4. These are based on the records from the H10 form of the Texas RRC[8]. Figure 24 is a map of eastern Texas with the county water volumes. Guadalupe County near San Antonio has the largest volumes for 2007 and more than double the per well injection rate. In East Texas, Gregg and Upshur Counties are the two counties with the highest injection rates. Johnson County, in North-Central Texas, is unique in going from no disposal in wells in 2002 to having the 10th largest volume in 2007. The amount of fluid a formation has injected into it gives an indication as to how much is available for production. Therefore, deep (>10,000 ft) injection wells with high disposal rates are considered one initial indicator of where to explore for geothermal development.

Table 4. The total volume of well injection and disposal in barrels (BBLS) for each county during the years 2002 and 2007.

COUNTY	2002 BBLS	BBLS/day '02	2007 BBLS	BBLS/day '07	# of wells	BBLS/well '07
BRAZORIA	76,018,663	208,270	82,961,267	227,291	114	727,730
CALDWELL	85,350,824	233,838	126,802,271	347,403	82	1,546,369
FORT BEND	40,404,936	110,698	2,988,225	8,187	98	30,492
GREGG	162,441,485	445,045	171,657,048	470,293	68	2,524,368
GUADALUPE	137,000,401	375,344	316,642,226	867,513	54	5,863,745
HARRIS	41,152,107	112,745	37,261,790	102,087	149	250,079
JACKSON	55,276,969	151,444	44,467,697	121,829	133	334,344
JOHNSON	0	-	65,750,533	180,138	24	2,739,606
MONTGOMERY	39,537,722	108,323	49,856,560	136,593	54	923,270
RUSK	85,265,556	233,604	102,776,570	281,580	184	558,568
STEPHENS	179,602,280	492,061	208,317,611	570,733	683	305,004
UPSHUR	129,415,393	354,563	130,498,073	357,529	44	2,965,865
VAN ZANDT	36,564,117	100,176	29,701,971	81,375	45	660,044
WICHITA	71,703,725	196,449	72,771,002	199,373	1450	50,187
WOOD	78,710,794	215,646	68,851,192	188,633	140	491,794

[8] http://webapps.rrc.state.tx.us/H10/h10PublicMain.do

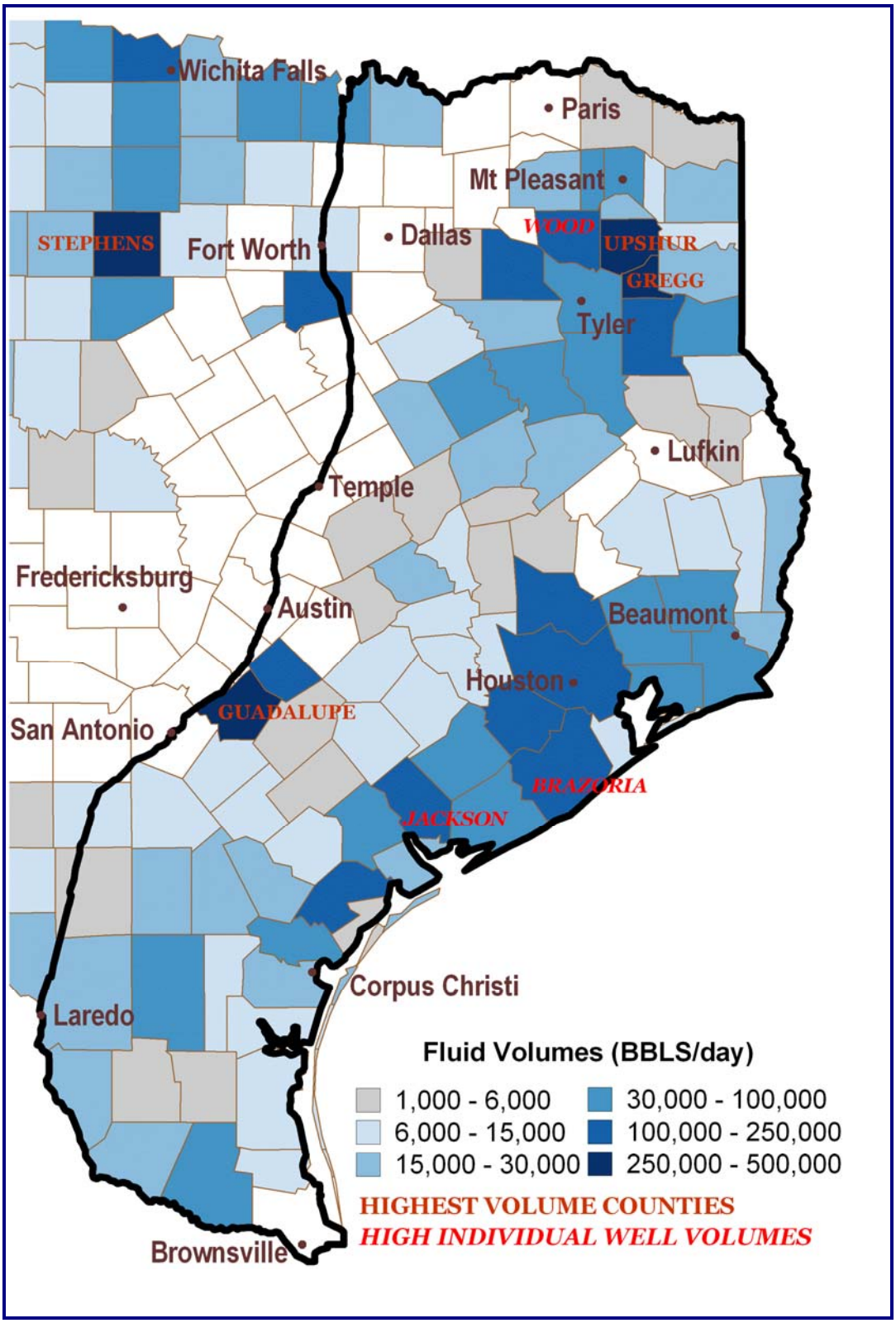

Figure 24. Map of eastern Texas with counties shaded according to their combined injection and disposal volumes.

Available Wells

There are various methods of exploration to determine which wells within a field are the "low-hanging-fruit" for geothermal exploration. The ability to extend the life of a field and use existing wells leads to the review of wells in line for plugging and abandonment. During the last three years, there have been 19,328 wells plugged in Texas (Table 5). For the I-35 study area which includes RRC Districts 1 - 6, there have been 2,684 wells abandoned in 2009 alone. By comparing data within the SMU-TX RRC Database, 47% were deeper than 10,000 feet and 54% were greater than 250°F. Therefore, it is estimated that 45 to 55% of the wells abandoned in 2009 were capable of geothermal energy production. If 50% of these wells (from Districts 1 - 6) were converted and had a minimal energy output of at least 250 kW, eastern Texas could continuously generate 335,500 kW (33.5 MW) of base load power. Using the current availability for geothermal power plants at 94%, then 2,762,641,200 kW/hours of electricity per year could be produced from the wells instead of them being plugged. That is enough for 8,400 homes or a whole county in some cases.

Table 5. Texas RRC Summary of Drilling, Completions, and Plugging Reports for 2009.

	Year Summary			TX RRC Districts for 2009					
	2009	2008	2007	1	2	3	4	5	6
Drilling Overview									
New Drill Dry/Completions	12,937	15,255	12,291	499	342	481	986	687	1,345
Re-Enter Dry/Completions	509	513	369	19	7	22	8	0	8
Re-Completions	1,852	1,615	1,638	100	187	178	195	82	103
Total Completions	15,279	17,337	14,247	618	536	680	1,188	768	1,456
Oil Completions	5,860	6,208	5,084	460	117	298	81	42	118
New Drill	4,618	5,202	4,051	365	49	212	60	37	95
Re-Enter	239	259	186	17	2	14	1	0	2
Re-Completion	1,003	747	847	78	66	72	20	5	21
Gas Completions	8,706	10,361	8,643	135	409	349	1,096	706	1,307
New Drill	7,933	9,501	7,853	114	291	245	918	630	1,225
Re-Enter	43	72	67	2	5	6	6	0	3
Re-Completion	730	788	723	19	113	98	172	76	79
Injection/Other Completions	713	768	520	23	10	33	11	20	31
Total Holes Plugged	6,390	6,046	6,892	498	350	562	690	226	358
Completed Holes	6,371	6,000	6,841	498	350	561	689	225	316
Oil	3,991	3,855	4,682	406	86	318	242	161	169
Gas	1,916	1,636	1,620	83	250	219	422	33	135
Other	464	509	539	9	14	24	25	31	12
Dry Holes Drilled.Plugged	19	46	51	0	0	1	1	1	0
New Drill	17	45	49	0	0	1	1	1	0
Re-Enter	2	1	2	0	0	0	0	0	0

http://www.rrc.state.tx.us/data/drilling/drillingsummary/2009/annual2009.pdf

Other wells considered "available" are those used in secondary recovery applications. The best case scenario is where produced water is directly connected to an injection well. This situation

allows for a binary turbine to be installed between the two wells with minimal infrastructure changes necessary. As shown in Table 5, the quantity of the fluid being injected or disposed of is huge. For the combined volumes of Districts 1 - 6 the total amount was 2,172,701,192 barrels in 2007. The average barrels per well was 364,242. Over half of the fluid was used for secondary recovery. There are currently 2,237 secondary recovery injection wells in District 1 - 6 that could be reviewed for depth and interconnection within the hydrocarbon field to see if they are injecting into formations with temperatures over 200°F.

Enhanced Geothermal Systems Resource

Enhanced Geothermal Systems (EGS) are developed in geologic formations with limited quantities of water but at high temperatures (Tester et al., 2006). These formations become productive when fluid is injected into the rock to act as a carrier for the extraction of heat. This type of geothermal resource potential is huge in comparison to other geothermal categories in Texas because it utilizes deeper - hotter resources and therefore has higher conversion efficiency. EGS can essentially be developed anywhere at any well depth where temperatures of 300°F or higher exist. The horizontal drilling and multiple stage fracturing techniques in common use today are forming potential EGS geothermal reservoirs in many wells at many locations. Texas has the advantage of using the sedimentary basins, hydrocarbon knowledge, and existing well situations to increase the possibility of near-term development of EGS.

The EGS resources occur because of heat conducting from the Earth's interior and natural radioactivity within the rocks. The basement rock of the Sabine Uplift in East Texas is considered the area with the highest heat flow in Texas (Blackwell and Richards, 2004a) (Figure 1). Here the potential for EGS is the greatest, especially if combined with coproduction of oil and gas from the upper formations. The calculated subsurface temperatures in East Texas are 400°F at 20,000 ft (Negraru et al., 2008). A realistic EGS potential for Texas is 318,652 EJ (Negraru et al., 2008) with the majority of the thermal energy from the eastern half of the state because the Permian Basin is relatively low temperature at similar depths to east Texas. For a perspective as to how much 318,652 EJ of EGS resources can produce, using an average binary turbine conversion rate of 10% from thermal energy to electrical production, and a very conservative availability rate of 0.2%, there is enough to power the entire industrial sector for over 500 years at

the 2008 Texas electrical consumption rate of 32,525 thousand megawatt-hour (MWh)[9]. Even modest utilization of this EGS resource is capable of supplying a large portion of the state's energy on a permanent baseload basis.

Direct Uses of Geothermal Resources

Many of the wells in Texas are drilled to depths where the temperatures are less than 200°F. In these situations, the water production can be reviewed for specific economic applications. Use of the warm to hot water for commercial applications or community space heating is referred to as "Direct Use". For instance, John et al., (1998) determined the following applications from the Gulf Coast geothermal - geopressured wells: the heating of houses, sulfur extraction, coal desulfurization, chemical processing, extraction of chemicals from brine, water desalination, fish rearing, greenhouse heating, cane sugar processing, lumber drying etc.

Absorption chillers use heat instead of mechanical energy to provide cooling. This is another application for using the produced warm to hot water. While most vapor compression chillers require electricity to operate the machine, absorption chillers use heat, typically in the form of steam or hot water. The absorption chiller is designed for large applications such as hospitals, industrial settings, high-rise offices, so this is a direct use for wells that are being drilled within city limits or near a specific end user site.

For existing oil and gas fields in rural areas, direct use applications can be added at the surface for increased productivity of all the resources. Direct use applications are common in the western United States. Agencies willing to assist in project development are the USDA, Rural Alliance for Renewable Energy (RARE), and National Renewable Energy Laboratory (NREL) - DOE EERE - Geothermal Program.

Heavy Oil Extraction

The Southwest Texas Heavy Oil Province is the largest heavy oil resource in the Gulf Coast region, primarily located in Zavala, Maverick, Uvalde and Kinney counties. It is found from depths of 0-3000 feet. Potentially it is the second-largest identified reservoir in the United States (Ewing, 2005). In 1994, Seni and Walter researched the use of geothermal energy to extract

[9] http//:www.eia.doe.gov

heavy oil in South Texas. To determine how much of the resource was left, they compared the overall sizes and extraction rates of different reservoirs. Thus "medium- and heavy oil reservoirs constitute 10% of the large oil reservoirs in Texas, their cumulative production represents only 8.4% of the production from the large oil reservoirs. The 1.6% difference is a result of the lower average productivity and is equivalent to a difference of 629 MMbbls ($1.0 \times l0^8$ m^3) (or 1.6% x total cumulative production of large reservoirs in Texas)." This is one resource target still available for production in conjunction with geothermal energy development.

The heavy-oil reservoirs are concentrated in the Jackson Group, Cole sandstone, whereas medium-oil reservoirs are concentrated in the Government Wells, Lorna Novia, and Mirando sandstones within the same area. The medium oil resource is larger than the heavy oil resource. This allows for a multi-level resource development using medium oil, heavy oil and geothermal resources. The geothermal resources reach temperatures of over 350°F and are below the oil reservoirs.

The San Miguel 'D' sandstone (2,100 feet depth) was targeted for heavy oil research in the early 1980s, when Exxon and Conoco produced 417,673 barrels from pilot plants (Ewing, 2005). The viability of using the geothermal-geopressured resources was studied again in 1991 as part of a Department of Energy research project (Negus-de Wys et al., 1991). The conclusions at that time were that the break-even price for oil needed to be $14/barrel and gas $2 per thousand cubic feet. Using those figures, at the time there would be a payback in less than two years. The study included a pilot project using the Alworth Field in South Texas and the Wilcox Formation for a water source at fluid temperatures of 250°F to 500°F between 16,000 and 18,000 feet. Seni and Walter (1994) continued to study the heavy oil extraction, concluding that this was the best area to test the viability of using geopressured-geothermal fluids to improve oil recovery. They noted that the Upper Wilcox geopressured-geothermal reservoirs will produce approximately 1,000 to 2,000 barrels per day of fluids. These rates are adequate to test the geothermal technology and evaluate engineering data on South Texas geothermal and heavy oil reservoirs.

During the past few years oil prices (USO) fluctuated between $117 and $40 per barrel and the natural gas fund (UNG) between $63 and $8, showing how much variation there can be in the market. The current focus on renewable energy may contribute to renewed interest. With the need for energy continuing to increase, as Ewing (2005) stated, "this resource deserves another look."

DEVELOPMENT and COMMERCIALIZATION

Legal Aspects

According to the Texas Geothermal Resources Act of 1975, "Geothermal energy and associated resources" means: (1) all products of geothermal processes, embracing indigenous steam, hot water and hot brines, and geopressured waters; (2) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (3) heat or other associated energy found in geothermal formations; and (4) any by-product derived from them. The term "by-product" means any element found in a geothermal formation which when brought to the surface is not used in geothermal heat or pressure inducing energy generation" (Oberbeck, 1977). The Railroad Commission of Texas, Oil and Gas Division, has defined geopressured aquifers under its documentation "Rules having Statewide General Application to Oil, Gas, and Geothermal Resource Operations within the State of Texas," (March 1982) as "a geopressure aquifer as having a pressure of greater than 0.5 pounds per square foot of depth and a temperature gradient in excess of 1.6°F per 100 feet of depth. The Texas Geothermal Resources Act of 1975 was amended in Vernon's Texas Codes Annotated, Natural Resources, Section 141.002(5) to clarify "*by-products*" as: "any other element found in a geothermal formation which is brought to the surface, **whether or not** it is used in geothermal heat or pressure inducing energy generation". This indicated that methane entrained in geothermal fluids is considered part of the geothermal resource which includes by-products, (Sherk, 1982).

As geothermal energy is developed in Texas, there will be legal discussions. According to the SMU Geothermal Energy Utilization Conference presentations by Stepp (2009) and Gibson (2009) examples of potential legal issues include:

- Debate of ownership between the surface owner and mineral right owner.
- How does the rule of capture and trespass by fracturing impact geothermal projects?
- Is the brine fluid still categorized as drainage if other valuable minerals are extracted from the fluid but the remaining fluid or gas continues through the binary system?
- What if the valuable mineral is really defined as a waste in Texas but is now being used productively?
- If CO_2 is utilized as a heat transmitter, and not emitted when extracted from the hydrocarbons is it considered a "waste"?
- Mineral owner may be liable for waste if not capturing heat from produced water.

The most recent legislation is the Texas House Bill 4433, September 2009, which is an exemption from the severance taxes on oil and gas incidentally produced in association with the production of geothermal energy. The Texas Comptroller office is working on the determination of incidentally.

Business Development

Leasing and development of geothermal projects have been occurring for the last 40+ years in the United States. Yet the business plan for developing low-temperature (< 300°F) geothermal projects in areas outside of the Western United States is still considered "risky" (Dunn, 2010). According to the Department of Energy, geothermal energy has one of the lowest levelized costs (cost of power production over the life of a power plant) of any form of power, renewable or nonrenewable! The biggest risk for geothermal project development is the capital needed on the front-end. Potentially this can be as high as 95% of the capital budget (Dunn, 2010). In the last few years, there are now companies with a business plan to develop geothermal energy in relationship to oil and gas fields. Since there are many different scenarios for geothermal development, a series of questions were compiled to assist in new development, see Appendix D.

Technology Changes and Impacts

How much energy can be produced from one well? This is a common question. The simple answer is that it varies with temperature, fluid flow rates, and the type of technology used for the power plant. An initial set of calculations are shown in Appendix C for calculating the electrical production that will show how changing the different parameters (i.e., casing size, flow rates, thickness of lithology) impacts the electrical output.

The improvement in binary geothermal technologies to use lower temperature geothermal wells has resulted in renewed emphasis on developing the Texas geothermal resource. A paradigm shift for the geothermal industry was started in 2006 when the lowest temperatures currently in production dropped to 165°F at Chena Hot Springs, Alaska. The Pratt & Whitney Power System (PWPS) PureCycle® changed the focus on geothermal resources from sites using approximately 300°F+ producing 1 - 10s of MW of electricity to low temperature (165 - 300°F) sites producing as few as 50 kW with new technologies. In October 2008, the ORMAT Technologies Company installed a binary plant at the Rocky Mountain Oilfield Testing Center (RMOTC) operating on a

195°F fluid from a series of oil striper wells in the Tea Pot Dome field, Wyoming. This installation was the first commercial application of coproduction. In recent years, new products have entered the electrical power market with designs starting as low as 180 to 200°F in Texas with a required delta T of approximately 100 to 120°F between the hot and cold fluid sources (Appendix D).

Using different technologies, there are four new geothermal power demonstrations currently underway. In Texas, there is a DOE demonstration in Liberty County, just north of Houston that is designed to generate 250 kW. The developer is Universal GeoPower LLC, and they will be using the PWPS PureCycle®. There is a second DOE demonstration along the Gulf Coast of Louisiana in progress by Louisiana Geothermal LLC. Using the ElectraTherm Green Machine there are two projects in this region. One is a RPSEA project in central Mississippi deployed by Gulf Coast Green Energy using a Denbury Resources well. The second is a project Hilcorp Energy Company and Cleco Utility Company are developing in western Louisiana. Both projects are expected to be 50 kW or less. Other companies are actively proceeding to develop geothermal power in Texas, such as the GeoPower Texas Company has purchased the rights for geothermal leases from the Texas General Land Office for wells off-shore along Galveston, Brazoria, and Matagorda Counties.

The current technologies are based on either temperature or pressure or both for generating electricity. These power plants are small, easily transportable and efficient enough to produce small amounts of electricity; yet can be scaled-up to produce MWs. The purpose is to tap into small applications that have been previously overlooked by the large-scale power plant development companies. Texas has the capability to use the geothermal resources in large-scale (MWs) production: converting an entire oil field into a geothermal field, EGS projects, or geopressured-geothermal development. It is also prime for the start-up project for mini power plants (kWs) on low flow, low temperature sites.

CONCLUSIONS

Geothermal energy power production is a renewable baseload resource. Through reservoir engineering and proper management of the resource the necessary heat extraction can be maintained over decades. The use of sedimentary basins and geopressured formations are the initial entry points for companies in Texas to develop geothermal electrical production.

Developing existing hydrocarbon fields into geothermal electrical production has the quickest potential for tapping into the thermal energy resource stored under Texas.

The Future of Geothermal Report (Tester et al., 2006) suggests Enhanced Geothermal Systems (EGS) could be a sustainable source of energy. There will be initially high costs for development that will then decrease as technology, knowledge, and market growth improve. Texas has the resources to be one of the proving grounds for EGS through use of deep sedimentary basins, and in doing so, decrease the initial EGS drilling and reservoir engineering expenses. The geothermal - geopressured zones in South Texas are where the heat flow and temperatures are highest in Texas. This is the area of highest temperatures reaching over 350°F at 12,000 feet, over 450°F at 19,000 feet, and over 500°F at 23,500 feet. Unlike the Gulf Coast geopressured areas, the amount of fluid available for production in South Texas at these depths is not quantified, but shallower depths have lower permeability. These deeper formations are a candidate for EGS geothermal projects. With the EGS projects currently under development in Australia, Europe, and western United States, an EGS project development in Texas is definitely viable.

Along with the use of EGS resources in South Texas for electrical production, the geothermal resource can be used to increase the production of heavy oil. The areas for EGS are collocated with the heavy-oil reservoirs. The ability to cascade the use of the produced water with other industries increases the economic viability of a project. The power plants are not able to extract all the heat from the fluid stream, leaving heat for other applications. Geopressured-geothermal resources can also be used for applications such as absorption chillers, desalination, agriculture, and aquaculture projects. Geothermal energy can be teamed with other renewable energies that are surface land space intensive.

One advantage of the new less than 1 MW geothermal power plant technology is the scalability and development in configurations that are either distributed or centralized. Geothermal power plants have a very small footprint and therefore can be installed as part of a neighborhood, or a commercial building. This could directly reduce the usual 59% of the electricity normally lost to generation, transmission, and distribution[10].

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[10] 2006, http://www.eia.doe.gov/.

Using information from existing oil and gas wells, tens of thousands of temperature data points can be used as an exploration tool for defining the most accessible resource locations. The temperatures from well log records can be corrected for in-situ temperatures, or pressure temperature data can be used as a proxy for equilibrium temperature. Although temperature at depth is only the initial starting point for reviewing potential resources, the extent of BHT data in Texas is huge with over 600,000 wells currently on record. This assessment shows that the general trend of temperatures in Texas is wide sweeping and that by 10,000 feet many areas are hot enough to generate electricity with current technology. There are wells within every district in this study that have elevated gradients and need further study of the geologic conditions to determine if some are more favorable than others for site specific development.

Geothermal development in Texas is on the cutting edge, yet it is a resource that has been examined multiple times in the past. Every time is has been deemed a worthwhile target. With multiple power projects underway currently in the Gulf Coast region and many companies looking into how to tap the resource economically, the time for Texas to become a leader in geothermal energy is starting to come to fruition. This is a new beginning for the geothermal energy industry in Texas.

General Considerations

- Many BHTs are needed to define a temperature profile for an area. BHTs can have differences of 25°F between neighboring wells because of the impact from drilling fluids.
- New regulations are needed for brine production data from an individual well. This is more useful than injection data from a series of wells for companies looking for locations to install binary turbines at the well head. The injection data is helpful to see how much fluid is produced from a field, representing the permeability of the producing formations.
- Corrections to the BHT data typically increase the measured temperatures by about 30°F at 9,000 feet to about 34°F at 12,000 feet. The corrected temperatures are better estimates the in-situ temperature value for the producing formation.
- Policy from both the Texas and Federal government agencies is still considered the main method to move an industry into a new direction. The 2009 Texas Severance Tax Exemption for geothermal (HB 4433) and the continued focus of the Texas Public Utility Commission to increase renewable energy development in Texas is a positive step. There is increased funding from the Department of Energy for geothermal projects in low-temperature environments which should also make a difference.
- Marketing of geothermal energy development is of the utmost importance to reach the public and create momentum in the power utility and oil and gas industries.

BIBLIOGRAPHY

NOTE: Many references give an OSTI #. These documents are available to download at http://www.osti.gov.

AAPG, 1994. American Association of Petroleum Geologist (AAPG), CSDE, COSUNA, and Geothermal Survey Data_Rom.

Bebout DG., Weise, BR., Gregory, AR., Edwards, MB., 1982. Wilcox sandstone reservoirs in the deep subsurface along the Texas Gulf Coast: their potential for production of geopressured geothermal energy. Report of Investigations No. 117, DOE Technical Report DOE/ET/28461-T2, 193 p. OSTI # 6140725.

Bebout, DG., Loucks, RG., Gregory, AR., 1983. Frio sandstone reservoirs in the deep subsurface along the Texas Gulf Coast: their potential for production of geopressured geothermal energy. UT Austin Bureau of Economic Geology, DOE Technical Report NP-4901171, 117 p. OSTI #6934141.

Blackwell, David and Maria Richards, 2004a. Geothermal Map of North America. AAPG Map, scale 1:6,500,000, Product Code 423.

Blackwell, D.D. and Maria Richards, 2004b. Calibration of the AAPG Geothermal Survey of North America BHT data base. AAPG Annual Meeting, Dallas, TX, Poster session, paper 87616. http://smu.edu/geothermal/bht/aapg04%20blackwell%20and%20richards.pdf

Blackwell, David, and Robert Spafford, 1987. Experimental methods in continental heat flow. Experimental Methods in Physics, 24, Geophysics; Part B; Field Measurements, ed. C.G. Sammis and T.L. Henyey, Academic Press, Orlando, p. 189-226.

Blackwell, DD., Beardsmore, GR. and Wisian, KW., 1997. Thermal structure of the Bayou Bleu salt dome, Louisiana from precision temperature logs and thermal conductivity measurements, a report for: Mobil Exploration and Production Technology Company, 37 p.

Blackwell, David, Negraru, Petru, Richards, Maria, 2006. Assessment of the enhanced geothermal system resource base of the United States. Natural Resources Research, Springer Netherlands, v 15/4, 283-308, DOI 10.1007/s11053-007-9028-7.

Blackwell, DD., Wisian, KW., Nishimori, RK., and McMullen, RJ., 1998. High resolution temperature logs in a petroleum setting: examples and applications, pp. 1-34, in Geothermics in Basin Analysis, eds A. Forster and D.F. Merriam, Plenum Press: New York.

Bliss, JD., 1983. Texas - basic data for thermal springs and wells as recorded in GEOTHERM. U.S. Geological Survey Open-File Report 83-436, 437 p.

Burns, Steven W., 2004. Depositional environments and associated facies of the Late Jurassic Bossier Formation, Freestone County, East Texas Basin. Southern Methodist University Master's Thesis.

Davis, RJ., Conover, MF., Keeney, RC., Personett, ML., Richmann, DL., 1981. Texas Geothermal RD&D Program Planning. Texas Energy Development Fund, TENRAC/EDF-045, DE83900796, 270 p. OSTI # 6589426.

DeFord, RK., and Kehle, RO., 1976. Geothermal gradient map of North America. AAPG and USGS, scale 1:5000000.

Dorfman, MH., and Morton, RA., 1983. Technology transfer of geopressured/geothermal resources to industry. Conference: 2nd Annual DOE Geothermal Progress Review, Washington, DC, p. 289-300. OSTI # 7369618.

Dunn, Craig, 2010. Geothermal energy investment: A risky bridge to cross? North American Clean Energy, Jan/Feb 2010, p. 59.

Edwards, Tom, 1974. The impact of state and Federal law on development of geothermal resources in Texas. State of Texas, Governor's Energy Advisory Council, Legal and Regulatory Policy Committee (Austin), 52 p. OSTI # 7361940.

Erdlac, Richard, 2006. A resource assessment of geothermal energy resources for converting deep gas wells in carbonate strata into geothermal extraction well: A Permian Basin evaluation. UT Permian Basin Center for Energy & Economic Diversification DOE Technical Report DOE/GO/85023. OSTI # 893183.

Erdlac, Richard, 2008. A systematic approach to geothermal power classification. SMU Conference: Geothermal Energy Utilization Associated with Oil and Gas Development, Dallas Texas. http://www.smu.edu/geothermal.

Erkan, Kamil, Holdmann, G., Benoit, W., Blackwell, D. 2007. Understanding the Chena Hot Springs, Alaska, geothermal system using temperature and pressure data from exploration boreholes. Geothermics, pp. 565-585.

Ewing, Thomas E., 2005. The Southwest Texas heavy oil province—a ten-billion-barrel resource. AAPG Annual Meeting, Calgary, Alberta. Search and Discovery Article #90039.

Geothermal Program Review X, 1992. Proceedings. Geothermal Energy and the Utility Market -- the opportunities and challenges for expanding geothermal energy in a competitive supply market. CONF-920378, 230 p. OSTI # 10171825.

Gibson, M., 2009. Geothermal leases and the regulatory environment. SMU Conference: Geothermal Energy Utilization Associated with Oil and Gas Development, Dallas Texas. http://www.smu.edu/geothermal.

Gregory, AR., 1977. Engineering parameters used in geopressured -geothermal fairway evaluation and test -well site location, Frio Formation, Texas Gulf Coast. Third geopressured-geothermal energy conference. V. 1, p. GI-349 - GI-424. OSTI # 7369254

Gregory, AR., Dodge, MM., Posey, JS., and Morton, RA., 1980. Volume and accessibility of entrained (solution) methane in deep geopressured reservoirs-Tertiary formations of the Texas Gulf Coast. DOE Final Report DOE/ET/11397-1, 361 p. OSTI # 5282675. (Data used from report for this 2010 assessment.)

Gregory, AR., Dodge, MM., Posey, JS., and Morton, RA., 1981. Assessment of in-place solution methane in tertiary sandstones: Texas Gulf Coast. 5th Geopressured-Geothermal Energy Conference, Baton Rouge, LA, CONF-811026-4, p. 25-28. OSTI # 6282303.

Griggs, Jeremy, 2004. A Re-evaluation of geopressured-geothermal aquifers as an energy resource. Louisiana State University Master's Thesis. http://etd.lsu.edu/docs/available/etd-07082004-102126/.

Harrison, WE., and Luza, KV., 1985. Monitoring temperature conditions in recently drilled nonproductive industry boreholes in Oklahoma. DOE Technical Report DOE/ID/12172-T2, 41 p. OSTI # 5463705.

Harrison, WE., Prater, ML., and Cheung, PK., 1982. Geothermal resource assessment in Oklahoma. Oklahoma Geological Survey Special Publication SP 83-1, 42 p., 1983.

Harrison, WE., Luza, KV., Prater, M.L., and Cheung, PK., 1982. Geothermal resource assessment in Oklahoma. In the Geothermal Direct Heat Program Roundup Technical Conference Proceeding, V. 1, editor Carl Ruscetta, pp. 187 - 204. OSTI # 6666263.

Jackson, S., Chang, MM, Tham, M., 1993. Data requirements and acquisition for reservoir characterization. National Inst. for Petroleum and Energy Research, Bartlesville, OK, Report NIPER-615, 28 p. OSTI # 6682294.

John, Chacko, Maciasz, G., Harder, B., 1998. Gulf coast geopressured-geothermal program summary report compilation. Basin Research Institute, Louisiana State University, DOE Technical Report DE-FG07-95ID13366, Volume 1: Executive Summary. OSTI # 895335. Volume 2 A & B: Resource description, program history, wells tested, university and company based research, site restoration. OSTI # 661421 & 661418. Volume 3: Applied and direct uses, resource feasibility, economics. OSTI # 661423. Volume 4: Bibliography. OSTI # 661425.

Kehle RO., Schoeppel, RJ., and Deford, RK., 1970. The AAPG geothermal survey of North America, proceedings of the United Nations Symposium on the development and utilization of geothermal resources. Geothermics, Special Issue 2, Vol. 2, p. 358-367, 1970.

Loucks, RG., Dodge, MM., Galloway, WE., 1979. Sandstone consolidation analysis to delineate areas of high-quality reservoirs suitable for production of geopressured geothermal energy along the Texas Gulf Coast. UT Austin Bureau of Economic Geology, DOE Technical Report ORO-5554-1, 103 p. OSTI 5754234.

Loucks, RG., Richmann, DL., Milliken, KL., 1981. Factors controlling reservoir quality in tertiary sandstones and their significance to geopressured geothermal production. UT Austin Bureau of Economic Geology, DOE Technical Report DOE/ET/27111-T3, 45 p. OSTI # 5097180.

Lunis, BC., Negus-deWys, J., Plum, MM., Lienau, PJ., Spencer, FJ., Nitschke, GF., 1991. The feasibility of applying geopressured-geothermal resources to direct uses. DOE Technical Report EGG-EP-9839, 130 p. OSTI # 5975559.

Morton, RA., Ewing, TE., Kaiser, WR., Finley, RJ., 1983. Consolidation of geologic studies of geopressured geothermal resources in Texas. 1982 annual report DOE/ET/27111-10, 205 p. OSTI # 5839276.

McKenna, Jason, Blackwell, DD., Moyes, C., and Patterson, PD., 2005. Geothermal electric power supply possible from Gulf Coast, Midcontinent oil field waters. Oil & Gas Journal, Sept. 5, p. 34-40.

Muehlberger, WR., Denison, RE., and Lidiak, EG., 1967. Basement rocks of the continental interior of the United States. American Assoc. of Petroleum Geologist Bulletin v. 51, pp. 2351-2380.

Nagihara, S., and Jones, KO., 2005. Geothermal heat flow in the northeast margin of the Gulf of Mexico. AAPG Bulletin; June 2005; v. 89; no. 6; p. 821-831; DOI: 10.1306/01170504057.

Nagihara, S. and Smith, MA., 2008. Regional overview of deep sedimentary thermal gradients of the geopressured zone of the Texas–Louisiana continental shelf. AAPG Bulletin, v. 92, no. 1 (January 2008), pp. 1–14.

Negraru PT., Blackwell, DD., and Erkan, K., 2008. Heat flow and geothermal potential in southwest United States. Natural Resources Research, vol. 17, no 4, p. 227-243. DOI 10.1007/s11053-008-9081-x.

Negus-de Wys, Jane, 1989. Properties of geopressured brines and wells in the Gulf Coast and opportunities for industrial/research participation. DOE 7th Geothermal Program Review, San Francisco, CONF-890352-10. OSTI # 5999731.

Negus-de Wys, Jane, 1990. The Geopressured-Geothermal Resource, research and use, Conference: The National Energy Strategy--the Role of Geothermal Technology Development. San Francisco, CA, CONF-9004131--2. OSTI # 6886699.

Negus-de Wys, Jane, Kimmell, C., Hart, G., Plum, M., 1991. The Feasibility of recovering medium to heavy oil using geopressured - geothermal fluids. Idaho National Laboratory DOE Report EGG-EP-9840,107 p. OSTI # 6248106.

Oberbeck, AW., 1977. The geopressured geothermal resources of Texas: A Report on Legal Ownership and Royalty Issues. University of Austin Center for Energy Studies, 58 p. OSTI # 6311964.

Plummer, FB., and Sargent, EC., 1931. Underground waters and subsurface temperatures of the Woodbine sand in northeast Texas. The University of Texas Bulletin, #3138, October, 178 p.

Randolph, PL., Hayden, CG., Mosca, VL., Anhaiser, JL., 1992. Testing of the Pleasant Bayou well through October 1990. Institute of Gas Technology and Eaton Operating Company USDOE Report for Contract DE-AC07-85ID12578. 218 p. OSTI # 6360574

Salvador, Amos, 1991. Origin and development of the Gulf of Mexico basin. Salvador, A., ed. The Gulf of Mexico Basin: Boulder, Colorado, Geological Society of America, The Geology of North America, Vol. J, p. 389-444.

SECO, 2008. Texas Renewable Energy Resource Assessment for the Texas Comptrollers Office, Chapter 7, Geothermal Energy. http://www.seco.cpa.state.tx.us/publications/renewenergy/.

Sellards, EH., Adkins, WS., and Plummer, FB., 1933. The Geology of Texas. University of Texas at Austin Bulletin No. 3232, 1007 p.

Seni, Steven and Jackson, MPA., 1983. Evolution of salt structures, East Texas Diapir Province, Part 1: Sedimentary Record of Halokinesis. American Association of Petroleum Geologists Bulletin V. 67, No, 8, August 1983, p. 1219-1244.

Seni, Steven and Timothy Walter, 1994. Geothermal and heavy-oil resources in Texas. UT Austin Bureau of Economic Geology, DOE Report DOE/NV/10412--6, OSTI # 140595. 52 p.

Sherk, George William, 1982. Development of geothermal energy in the States of Texas: Issues and legislative options. National Conference of State Legislatures' Geothermal Policy Project Research Report, November, 45 p.

Shook, GM., 1992. An Integrated approach to reservoir engineering at Pleasant Bayou geopressured-geothermal reservoir. Idaho National Laboratory Report EGG-EP-10557, 49 p. OSTI # 10146151.

Spicer, HC., 1964. A compilation of deep Earth temperature data. USA 1910-1945: USGS Open-File Report 64-147.

Stepp, Katherine, 2009. Texas precedence regarding trespass by fracture, rule of capture and its effect on the geothermal industry. SMU Conference: Geothermal Energy Utilization Associated with Oil and Gas Development, Dallas Texas. http://www.smu.edu/geothermal.

Tester, J., Anderson, B., Batchelor, A., Blackwell, D., DiPippo, R., Drake, E., Garnish, J., Livesay, B., Moore, M., Nichols, K., Petty, S., Toksoz, N., Veatch, R., Augustine, C., Baria, R., Murphy, E., Negraru, P., Richards, M., 2006. The future of geothermal energy: Impact of enhanced geothermal systems (EGS) on the United States in the 21st century. Massachusetts Institute of Technology, DOE Contract DE-AC07-05ID14517 Final Report, 374 p. OSTI # 911903.

Wallace, RH., Kraemer, TF., Taylor, RE., and Wesselman, JB., 1979. Assessment of geopressured - geothermal resources in the north Gulf of Mexico basin, p. 132-155 in Assessment of Geothermal Resource of the United States - 1978. Edited by Muffler LJP., US Geologic Surv. Circular 790.

Wisian, K., Blackwell, D., Bellani, S., Henfling, J, Normann, R, Lysne, P., Förster, A., and Schrotter, J., 1996. How hot is it? A comparison of advanced temperature logging devices. Geothermal Resources Council Transactions, p. 427-434.

Wisian, K., Blackwell, D., Bellani, S., Henfling, J, Normann, R, Lysne, P., Förster, A., and Schrotter, J., 1998. How field comparison of conventional and new technology temperature logging systems. Geothermics, 27:2, p. 131-142.

Woodruff, CM and McBride, MW., 1979. Regional assessment of geothermal potential along the Balcones and Luling-Mexia-Talco Fault Zones, Central Texas. Final Report UT Bureau of Economic Geology. OSTI # 5507385.

Woodruff, CM., Caran, SC., Gever, C., Henry, CD., Macpherson, GL., and McBride, MW., 1982. Geothermal resource assessment for the State of Texas. Bureau of Economic Geology, University of Texas. OSTI # 5915893.

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Appendix A

Summary of Major Geopressured - Geothermal Reports

The following section is a brief description of the major geopressured - geothermal reports based on the research completed during the 1970s to 1990s. The reports are listed in alphabetical order by the last name of the first author.

Bebout et al., 1982: This report did regional studies of the lower Eocene Wilcox Group in Texas to assess the potential for producing heat energy and solution methane from geopressured fluids in the deep-subsurface growth-faulted zone. However, in addition to assembling the necessary data for the geopressured geothermal project, this study has provided regional information of significance to exploration for other resources such as lignite, uranium, oil, and gas. Because the focus of this study was on the geopressured section, emphasis was placed on correlating and mapping those sandstones and shales occurring deeper than about 10,000 ft. The Wilcox and Midway Groups comprise the oldest thick sandstone/shale sequence of the Tertiary of the Gulf Coast. The Wilcox crops out in a band 10 to 20 miles wide located 100 to 200 miles inland from the present-day coastline. The Wilcox sandstones and shales in the outcrop and updip shallow subsurface were deposited primarily in fluvial environments; versus the downdip environment in the deep subsurface, the Wilcox sediments there were deposited in large deltaic systems, some of which were reworked into barrier-bar and strandplain systems. Growth faults developed within the deltaic systems, where they prograded basinward beyond the older, stable Lower Cretaceous shelf margin onto the less stable basinal muds. Continued displacement along these faults during burial resulted in: (1) entrapment of pore fluids within isolated sandstone and shale sequences, and (2) buildup of pore pressure greater than hydrostatic pressure and development of geopressure.

Bebout et al., 1983: From this research detailed geological, geophysical, and engineering studies conducted on the Frio Formation have delineated a geothermal test well site in the Austin Bayou Prospect which extends over an area of 60 square miles. A total of 800 to 900 feet of sandstone occurs between the depths of 13,500 and 16,500 feet. At least 30 percent of the sand has core permeabilities of 20 to 60 millidarcys. Temperatures at the top of the sandstone section are 300°F.

Water, produced at a rate of 20,000 to 40,000 barrels per day, will probably have to be disposed of by injection into shallower sandstone reservoirs. More than 10 billion barrels of water are in place in these sandstone reservoirs of the Austin Bayou Prospect; there should be approximately 400 billion cubic feet of methane in solution in this water. Only 10 percent of the water and methane (1 billion barrels of water and 40 billion cubic feet of methane) will be produced without reinjection of the waste water into the producing formation. Reservoir simulation studies indicate that 90 percent of the methane can be produced with reinjection.

Dorfman et al., 1983: This research, conducted by the Bureau of Economic Geology and the Center for Energy Studies, includes the following areas of interest; geological studies depicting pressure gradients and thermal gradients, sand distribution and fault patterns, all of which are used in petroleum exploration; geophysical data for interpretation of seismic velocities based upon lithologic changes and subsurface discontinuities; sandstone consolidation data involving changes of permeabilities with depth and diagenetic histories of Cenozoic rocks in the Gulf Coast Basin--this work also covers fluid migration pathways and resulting rock-water interactions and has led to a better understanding of generation, maturation and accumulation of hydrocarbons; work on salinity of formation waters covering several areas of study, such as chemical analysis to anticipate scale and corrosion problems, and investigations of logging techniques to better ascertain salinity from well logs; reservoir continuity studies, together with computational modeling to assist in estimation of ultimate recoveries and formation drives; rock mechanics studies, which have recently led to the development of new models to account for creep and determine compressibilities of sandstones and shales in geopressured environments; co-production of gas and water in watered-out gas reservoirs.

Edwards, 1974: This report attempts to locate geothermal resources within the general framework of Texas property law and to determine whether these resources can be developed under the law as it now exists. The significant geothermal resource in Texas consists of enormous reservoirs of hot, geopressured water, which formed along the Gulf Coast when water-laden sediments were deposited between surrounding impermeable features, so that the water which would otherwise have been forced out of the sediments was unable to escape. One of the impediments to the development of this resource, given the very sizable commitments of capital entailed, is the uncertain legal status of geothermal resources.

Geothermal Program Review X, 1992: The theme of the review, "Geothermal Energy and the Utility Market -- The Opportunities and Challenges for Expanding Geothermal Energy in a Competitive Supply Market," focused on the needs of the electric utility sector. Geothermal energy, with its power capacity potential of 10 GWe by the year 2010, can provide reliable, environmentally clean electricity which can help offset the projected increase in demand. The six technical sessions included presentations by the relevant field researchers covering DOE-sponsored R&D in hydrothermal, hot dry rock, and geopressured energy. Individual projects are processed separately for the databases.

Gregory et al., 1980: The objective of this project was to appraise the total volume of in-place methane dissolved in formation waters of deep sandstone reservoirs of the onshore Texas Gulf Coast within the stratigraphic section extending from the base of significant hydrocarbon production (8000 ft) to the deepest significant sandstone occurrence. The area of investigation is about 50,000 mi^2. Factors that determine the total methane resource are reservoir bulk volume, porosity, and methane solubility; the latter is controlled by the temperature, pressure, and salinity of formation waters. Regional assessment of the volume and the distribution of potential sandstone reservoirs was made from a data base of 880 electrical well logs, from which a grid of 24 dip cross sections and 4 strike cross sections was constructed. Solution methane content in each of nine formations or divisions of formations was determined for each subdivision. The distribution of solution methane in the Gulf Coast was described on the basis of five reservoir models. Each model was characterized by depositional environment, reservoir continuity, porosity, permeability, and methane solubility.

Griggs, 2004: This study shows commercial production of geopressured-geothermal aquifers is feasible under reasonable assumptions of natural gas and electricity price. However, the near-term likelihood of large-scale developments of geopressured aquifers is low. Factors that reduce the chance of near-term development include the availability of better exploration prospects, an uncertainty in current technology, and the lack of any current geothermal geopressured aquifer research programs. The medium-term development of geopressured aquifers relies on the sustainability of high natural gas prices, the application and acceptance of new technologies, and diversification of conventional exploration and production companies and electric utility companies. The long-term development of geopressured aquifers depends on the scarceness of conventional hydrocarbons.

Jackson et al., 1993: This report outlines the types of data, data sources and measurement tools required for effective reservoir characterization, the data required for specific enhanced oil recovery (EOR) processes, and a discussion on the determination of the optimum data density for reservoir characterization and reservoir modeling. The two basic sources of data for reservoir characterization are data from the specific reservoir and data from analog reservoirs, outcrops, and modern environments. Reservoir data can be divided into three broad categories: (1) rock properties (the container) and (2) fluid properties (the contents) and (3) interaction between reservoir rock and fluid. Both static and dynamic measurements are required.

John et al., 1998, Volume 1: The significant accomplishments of this program included (1) identification of the geopressured-geothermal onshore fairways in Louisiana and Texas, (2) determination that high brine flow rates of 20,000--40,000 barrels a day can be obtained for long periods of time, (3) brine, after gas extraction can be successfully reinjected into shallow aquifers without affecting the surface waters or the fresh water aquifers, (4) no observable subsidence or microseismic activity was induced due to the subsurface injection of brine, and no detrimental environmental effects attributable to geopressured-geothermal well testing were noticed, (5) sanding can be controlled by reducing flow rates, (6) corrosion controlled with inhibitors, (7) scaling controlled by phosphonate scale inhibitors, (8) demonstrated that production of gas from saturated brine under pressure was viable and (9) a hybrid power system can be successfully used for conversion of the thermal and chemical energy contained in the geopressured-geothermal resource for generation of electricity.

John et al., 1998, Volume 2A: This volume describes the following studies: Geopressured-geothermal resource description; Resource origin and sediment type; Gulf Coast resource extent; Resource estimates; Project history; Authorizing legislation; Program objectives; Perceived constraints; Program activities and structure; Well testing; Program management; Program cost summary; Funding history; Resource characterization; Wells of opportunity; Edna Delcambre No. 1 well; Edna Delcambre well recompletion; Fairfax Foster Sutter No. 2 well; Beulah Simon No. 2 well; P.E. Girouard No. 1 well; Prairie Canal No. 1 well; Crown Zellerbach No. 2 well; Alice C. Plantation No. 2 well; Tenneco Fee N No. 1 well; Pauline Kraft No. 1 well; Saldana well No. 2; G.M. Koelemay well No. 1; Willis Hulin No. 1 well; Investigations of other wells of opportunity; Clovis A. Kennedy No. 1 well; Watkins-Miller No. 1 well; Lucien J. Richard et al No. 1 well; and the C and K-Frank A. Godchaux, III, well No. 1.

John et al., 1998, Volume 2B: This volume describes the following studies: Design well program; LaFourche Crossing; MG-T/DOE Amoco Fee No. 1 (Sweet Lake); Environmental monitoring at Sweet Lake; Air quality; Water quality; Microseismic monitoring; Subsidence; Dow/DOE L.R. Sweezy No. 1 well; Reservoir testing; Environmental monitoring at Parcperdue; Air monitoring; Water runoff; Groundwater; Microseismic events; Subsidence; Environmental consideration at site; Gladys McCall No. 1 well; Test results of Gladys McCall; Hydrocarbons in production gas and brine; Environmental monitoring at the Gladys McCall site; Pleasant Bayou No. 2 well; Pleasant Bayou hybrid power system; Environmental monitoring at Pleasant Bayou; and Plug abandonment and well site restoration of three geopressured-geothermal test sites.

John et al., 1998, Volume 3: This volume describes the following studies: Geopressured-geothermal hybrid cycle power plant: design, testing, and operation summary; Feasibility of hydraulic energy recovery from geopressured-geothermal resources: economic analysis of the Pelton turbine; Brine production as an exploration tool for water drive gas reservoirs; Study of supercritical Rankine cycles; Application of the geopressured-geothermal resource to pyrolytic conversion or decomposition/detoxification processes; Conclusions on wet air oxidation, pyrolytic conversion, decomposition/detoxification process; Co-location of medium to heavy oil reservoirs with geopressured-geothermal resources and the feasibility of oil recovery using geopressured-geothermal fluids; Economic analysis; Application of geopressured-geothermal resources to direct uses; Industrial consortium for the utilization of the geopressured-geothermal resource; Power generation; Industrial desalination, gas use and sales, pollutant removal, thermal EOR, sulfur Frasch process, oil and natural gas pipelining, coal desulfurization and preparation, lumber and concrete products kilning; Agriculture and aquaculture applications; Paper and cane sugar industries; Chemical processing; Environmental considerations for geopressured-geothermal development.

John et al., 1998, Volume 4: This bibliography contains US Department of Energy sponsored Geopressured-Geothermal reports published after 1984.

Loucks et al., 1979: This study analysis of reservoir quality of lower Tertiary sandstones along the Texas Gulf Coast delineates areas most favorable for geopressured geothermal exploration. Reservoir quality is determined by whole core, acoustic log, and petrographic analyses. The Wilcox Group has good reservoir potential for geopressured geothermal energy in the Middle Texas Gulf Coast and possibly in adjacent areas, but other Wilcox areas are marginal. The

Vicksburg Formation in the Lower Texas Gulf Coast is not prospective. Reservoir quality in the Frio Formation increases from very poor in lowermost Texas, to marginal into the Middle Texas Gulf Coast and to good through the Upper Texas Gulf Coast. The Frio Formation in the Upper Texas Gulf Coast has the best deep-reservoir quality of any unit along the Texas Gulf Coast.

Loucks et al., 1981: This study discusses variable intensity of diagenesis as the factor primarily responsible for contrasting regional reservoir quality of Tertiary sandstones from the upper and lower Texas coast. Detailed comparison of Frio sandstone from the Chocolate Bayou/Danbury Dome area, Brazoria County, and Vicksburg sandstones from the McAllen Ranch Field area, Hidalgo County, reveals that extent of diagenetic modification is most strongly influenced by (1) detrital mineralogy and (2) regional geothermal gradients. The regional reservoir quality of Frio sandstones from Brazoria County is far better than that of Vicksburg sandstones from Hidalgo County, especially at depths suitable for geopressured geothermal energy production. However, in predicting reservoir quality on a site-specific basis, locally variable factors such as relative proportions for porosity types, pore geometry as related to permeability, and local depositional environment must also be considered. Even in an area of regionally favorable reservoir quality, such local factors can significantly affect reservoir quality and, hence, the geothermal production potential of a specific sandstone unit.

Morton et al., 1983: This study focuses on structural styles that are conducive to the development of large geothermal reservoirs include blocks between widely spaced growth faults having dip reversal, salt-withdrawal basins, and shale-withdrawal basins. These styles are widespread on the Texas Gulf Coast. Detailed structural mapping at several horizons in selected study areas within the Frio growth-fault trend demonstrates a pronounced variability in structural style. At Sarita in South Texas, shale mobilization produced one or more shale ridges, one of which localized a low-angle growth fault trapping a wedge of deltaic sediments. At Corpus Christi, shale mobilization produced a series of large growth faults, shale-cored domed anticlines, and shale-withdrawal basins, which become progressively younger basinward. At Blessing, major growth faults trapped sands of the Greta/Carancahua barrier system with little progradation. At Pleasant Bayou, a major early growth-fault pattern was overprinted by later salt tectonics - the intrusion of Danbury Dome and the development of a salt-withdrawal basin. At Port Arthur, low-displacement, long-lived faults formed on a sand-poor shelf margin contemporaneously with broad salt uplifts and basins. Variability in styles is related to the nature and extent of Frio sedimentation and shelf-margin progradation and to the presence or absence of salt.

Nagihara and Jones, 2005: Eighty-two seafloor heat-flow measurements were recently obtained across the Mississippi Fan region in the deepwater northeastern Gulf of Mexico. These data display an abrupt transition in heat flow between an area near the center of Pleistocene deposition (20 mW/m^2) and the eastern margin of the fan (40 mW/m^2). Although deposition of fan sediments has very likely suppressed the shallow subsea floor thermal regime, causing lower seafloor heat-flow values near the center, the magnitude and abruptness of the heat-flow contrast cannot be fully accounted for by the mechanisms related to sedimentary deposition, which include radiogenic heat production in sediments, pore-fluid migration, and presence of salt structures. The most plausible explanation for the sharp heat-flow contrast is that the heat released from the igneous basement is significantly greater in the eastern margin of the fan. The zone of contrasting heat flow lies along a previously suggested boundary between the oceanic crust and the thin transitional crust in the northeastern Gulf of Mexico. The area of higher heat flow coincides with the suggested zone of transitional crust, which, because of its granitic origin, generates greater amounts of radiogenic heat than oceanic crust. This finding opens up the possibility that heat-flow data may be used in delineating crustal lithologic boundaries along continental margins.

Negus-de Wys, 1989: This report summarizes geopressured reservoirs. In the Gulf Coast area the normal gradient is 0.465 psi/ft. Pressures may approach lithostatic pressure and have been measured as high as 1.05 psi/ft in the Gulf Coast area. Geopressured basins exist worldwide and in a number of U.S. locations, east, west, north and south. The Gulf Coast area has been studied extensively and is the subject of the DOE geopressured-geothermal research at present. The assumed ranges in resource characteristics include: depth from -12,000 to > -20,000 feet, brine flow rate from 20,000 to 40,000 bpd, temperature from 300 to 400 F, bottom-hole pressure from 12,000 to 18,500 psi; salinity from 20,000 to 200,000 mg/L, gas-water ratio from 40 to 80 scf/bbl., and condensate from a trace to production. Energy in the geopressured resource includes gas, thermal, and hydraulic energy. It has been estimated that there are 6,000 quads of methane and 11,000 quads of thermal energy in the Gulf Coast area geopressured-geothermal reservoirs. Estimates run as high as 50,000 quads for the thermal energy (Wallace et al., 1978). Present industrial interest in the Pleasant Bayou and Hulin wells includes: desalination plants, an economic study by a power company for regional use, use of generated electricity by a coalition of towns, aquaculture (catfish farming) research program, and an unsolicited proposal for enhanced oil recovery of heavy oil. Direct uses of the hot brine cover dozens of industries and processes. An example of multiple uses in the USSR is shown. Outside agency interest includes

the U.S.G.S., N.S.F., G.R.I., and possibly other areas within DOE. A research spin-off: a sensitive in-line benzene monitor has been designed by USL and will be tested in the near future. An in-line pH monitor is also under development for the harsh conditions of the geopressured-geothermal wells.

Negus-de Wys, 1990: This summary of the industry cost-shared proposals to the consortium, represented in the presentations included in these proceedings, attests to the interest developing in the industrial community in utilizing the geopressured-geothermal resource. Sixty-five participants attended these sessions, two-thirds of whom represented industry. The areas represented by cost-shared proposals include (1) thermal enhanced oil recovery, (2) direct process use of thermal energy, e.g., aquaculture and agriculture, (3) conversion of thermal energy to electricity, (4) environment related technologies, e.g., use of supercritical processes, and (5) operational proposals, e.g., a field manual for scale inhibitors. It is hoped that from this array of potential use projects, some will persist and be successful in proving the viability of using the geopressured-geothermal resource. Such industrial use of an alternative and relatively clean energy resource will benefit our nation and its people.

Shook, 1992: This research on modeling and prediction of geopressured-geothermal reservoirs is an excellent example of an engineering problem that can be solved through many different means. The problem may be approached from a purely numerical viewpoint, where a successful history match "demonstrates" the validity of the reservoir model, or from an analytical point of view. Each method has its own inherent limitations and weaknesses. Such limitations can be minimized by using some combination of both numerical and analytical methods, taking advantage of the strengths of each without the attendant weaknesses. This paper describes a combined numerical/analytical approach to reservoir engineering at the Pleasant Bayou geopressured-geothermal reservoir. A reservoir description had previously been developed, through which a successful history match was performed. Certain details of the reservoir can also be obtained through analysis of pressure and flow transients; these can then be used to constrain the numerical model. Methods for extracting such reservoir data are discussed, and the manner in which they can be used as constraints in the numerical models are presented.

Appendix B

Data used in this Assessment

1. SMU Geothermal Laboratory, TX Railroad Commission data collected for this project. Included in this appendix.
2. AAPG Geothermal Survey Well Data, 1994. This can be purchased through the AAPG Bookstore, Product Code 482. It includes: A. Exploratory Well File (CSDE), 1950-1989; B. Geothermal Survey of North America (GSNA), 1972; and C. Correlation of Stratigraphic Units of North America (COSUNA)
3. Gulf Coast Geopressure data, Gregory et al., 1980. Included in this appendix.
4. Freestone County Well data, Burns, 2004. Included in this appendix.
5. Fairway Field data, Hunt Oil Company and Kweik, 2008. Company data not included.
6. USGS GEOTHERM data for Texas, Bliss, 1983. This is only a portion of the entire dataset currently assessable.

Appendix C

Calculating the Potential Power from a Well

Calculating the potential power from the fluid temperatures and flow rates is the initial aspect to determining if a well/field should even be considered. The following materials from the Tester et al. (2006) Report, The Future of Geothermal Energy will assist in accomplishing this.

Using Figure 7.3 from Tester et al. (2006), the inlet and outlet temperatures can be used to determine the gross power output for a kilogram per second of fluid movement.

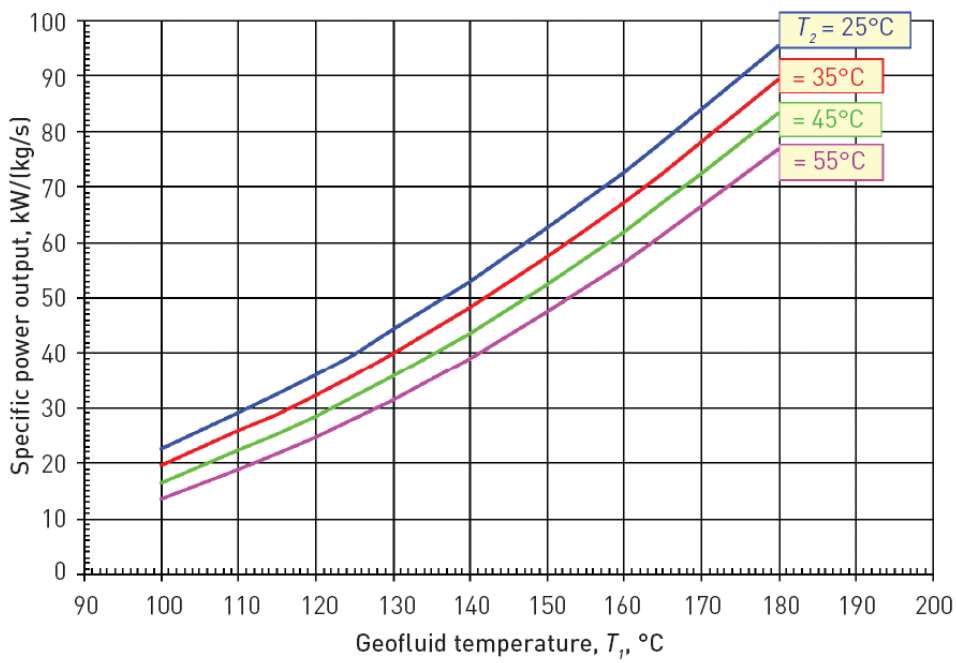


Figure 7.3 Specific power output (in kW/(kg/s)) for low- to moderate-temperature geofluids as a function of inlet (T_1) and outlet temperatures (T_2) shown in degrees Celsius (°C).

The 2006 Report used the example of 40°C (104°F) output (T_2) for its estimated power based on the yearly fluid for from the production of the oil and gas wells, as shown in Table 7.3. The output temperature will vary according to the initial (input) temperature, the cooling water temperature, the amount of total dissolved solids in the water, and the speed that the water is moved through the heat exchanger. Currently the output temperature varies between 49°C (120°F) in Chena Hot Springs, Alaska to approximately 67°C (152°F) at the Rocky Mountain

Oilfield Testing Center (RMOTC), Wyoming and is expected to be even hotter in Texas. In general the outlet temperature is generally about 10 to 40°C (18 to 72°F) cooler than the inlet temperature.

Within a State, well temperatures will vary greatly according to location and depth of resource. Table 7.3 from Tester et al., (2006) shows the MW capacity if all the flow is at each of the input temperature of 100°C, 140°C, or 180°C (212°F, 258°F, 355°F).

Table 7.3 Estimated power from California and Gulf states coproduced waters; outlet temperature assumed to be 40°C.

State	Flow rate, kg/s	MW @ 100°C	MW @ 140°C	MW @ 180°C
Alabama	927	16.6	42.3	79.9
Arkansas	1,204	21.6	54.9	103.7
California	2,120	37.9	96.7	182.5
Florida	753	13.4	34.3	64.8
Louisiana	9,786	175.2	446.3	842.6
Mississippi	2,758	49.4	125.8	237.5
Oklahoma	59,417	1,064	2,709	5,116
Texas	56,315	1,008	2,568	4,849
TOTALS	131,162	2,348	5,981	11,293

To change the watts (W) value, it is based on the change in outlet temperature (T_2) in comparison to the input temperature (T_1). Using the 2006 Report Figure 7.3 (above) and Equation 7.2 and Equation 7.3 below, new resource estimates can be compared.

Tester et al., (2006) Equation 7-2.

$$\frac{\Delta \dot{W}}{\Delta T_2} = 0.098701 - 0.0039645 T_1 .$$

Tester et al., (2006) Equation 7-3.

$$\dot{W}_{actual} = \dot{W}_{T2=40C} + \frac{\Delta \dot{W}}{\Delta T_2} \times (T_2 - 40).$$

Thus given an example from a well in Texas, with an input temperature of 121°C (250°F) and an outlet temperature of 107°C (225°F) we can use the equations to determine the new kW value. Using Figure 7.3, T_1 = 121°C and the correlated kW per kg/s for 40°C outlet temperature (halfway between the 35 and 45°C curves) is 31 kW.

Now using the equations the new value is:
kW = 31 + (0.098701 - 0.0039645*121°C) * (107°C-40°C)

kW = 5.5 per kg/s flow rate

In a second related example, if the outlet temperature (T_2) is decreased to 82°C (180°F) then the kW value increases to 14.9 kW per kg/s flow rate. More energy is being extracted for the same amount of flow. From this equation it shows that for the same drop in temperature, the higher inlet temperature (T_1) there is an increased amount of power (W) which can be produced.

Since the well temperature of 1000s of wells can not be easily used in determining the potential power, the tables give multiple temperature values to use as a range. Depending on if the average temperature of a group of wells is known, or estimated from the geology and heat flow, it is helpful to have more than one temperature estimate to give the possible range for a project. Table 7.3 gives initial input temperatures (T_1) to start from in estimating the total flow. From there the total flow rate can be manipulated, i.e., if you want to consider 50% of the wells at 100°C and 50% of the wells at 180°C.

One way to convert from bbl to kg/s, divide the bbl by 365.24 days/year to get bbls/day. Next bbls/day *.0004861 = gal/sec. From gal/sec * 3785.411784 to get cm^3/s. 1 gram of water is equal to 1 cm^3. Lastly multiply by .001 to get kg/s.

Example conversion:
Using Texas 12,097,990,120 bbl/year = 3312339.64 bbls/day
3312339.64 bbls/day *0.0004861 = 16,101.28 gal/sec
16,101.28 gal/sec * 3785.411784 = 60,949,990 cm^3/sec
60,949,990.49 cm^3/sec = 60,949,990.49 g/sec
60,949,990.49 g/sec *.001 = 60,949.99 kg/sec

To convert from kg/s to gpm, depending on the method of conversion, the conversion rate is either 15.81 (using kg to pounds to gallons) or 15.85 (using kg to liters to gallons). Therefore in working with the different units the accuracy of the final number will vary according the number of digits and method of conversion.

Calculating Potential Flow

By using Darcy's Law, which expresses radial liquid flow into a borehole in units of barrels of liquid per day, the open-flow potential of a well can be determined (Harrison et al, 1982). This can be used to review the available wells in an oil and gas field to get initial numbers for how much production can be expected to flow from a formation according to the borehole sizes.

$$bbl / day = 7.07kh(P_e - P_w) / \mu \ln(r_e / r_w)$$

where bbls/day = barrels per day (42 gallons/barrel)

k = permeability in darcies

h = interval thickness in feet

P_e = 1 atmosphere in psi (14.7 psi)

P_w = formation pressure in psi

μ = viscosity (1.0)

r_e = distance from well bore fluid will flow into it (660 feet is standard if unknown)

r_w = radius of well bore in feet

Calculating Coproduced Energy Content of Fluid

For geothermal wells situated in hydrocarbon fields, the fluids are usually mixed with oil and gas. Each of these has its own energy content, i.e., the heat from the water, and the separated oil and gas from the fluid stream. The following equations can be used to determine the entire energy value (million BTU) of the produced fluid. These were constructed by Efstathios (Stathis) Michaelides, Ph.D., P.E., Professor and Chair, Mechanical Engineering, University of Texas at San Antonio One UTSA Circle San Antonio TX 78249

Telephone - 210-458-5580 or Email - stathis.michaelides@utsa.edu.

The table below shows the Excel spreadsheet with the equations for the calculation.

	B	C	D
	Average Daily Flow Rates	**Input**	**Energy Content, MBTU**
3	Average daily barrels of oil (US bbls)		=C3*42*0.14
4	Average daily gas (scf)		=C4*400/1000000
5	Average daily barrels of saltwater (US bbls)		=C5*159*(C6-75)*2.2/1000000
6	Average fluid temperature at the wellhead (°F)		
	Percent of energy in saltwater		=D5/(D3+D5+D4)*100
	Total energy possible from well		**=SUM(D3:D5)**

The next table shows numbers in the Excel spreadsheet with an example of the calculations.

	B	C	D
	Average Daily Flow Rates	**Input**	**Energy Content, MBTU**
3	Average daily barrels of oil (US bbls)	***50***	294
4	Average daily gas (scf)	***10000***	4
5	Average daily barrels of saltwater (US bbls)	***15000***	918
6	Average fluid temperature at the wellhead (°F)	***250***	
	Percent of energy in saltwater		75.5
	Total energy possible from well		**1216**

Appendix D

Business Report Questions

Organizations and Companies to Contact for Assistance

Companies with Low-Temperature Technology

Phone: (214) 768-2749
Fax: (214) 768-2701
P.O. Box 750395
Dallas, TX 75275-0395
smu.edu/geothermal

Questions to Consider Before Starting a Geothermal Venture

Appendix D

Andrés Ruzo[1] Maria Richards[1] David Blackwell[1] Shannon McCall[2]

1. SMU Geothermal Laboratory
2. Telios Corporation

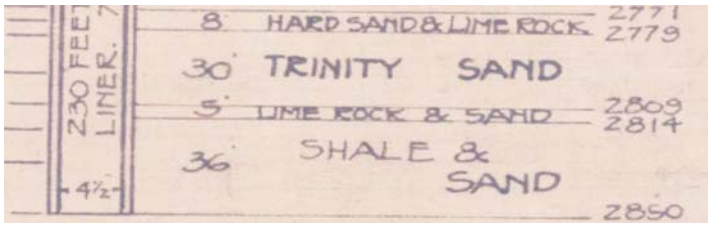
Executive Summary

The purpose of this document is to give those interested in developing geothermal resources and undertaking business ventures in the geothermal field an aid in the form of a basic checklist of things that should be considered when engaging in such a venture, in order to increase the probability of project success.

In any geothermal project there are four main areas that need to be considered in order to evaluate the potential success of the project. In the following pages we will expand on the specific questions that should be answered in the various analyses necessary for developing a geothermal project.

These areas include:

i.	Geologic	*Does the resource exist?*
ii.	Legal	*Can the resource be legally harnessed?*
iii.	Engineering	*Can the resource be efficiently harnessed?*
iv.	Financial	*Can the project be financed?*
		What are the Costs involved?



Geologic Investigation

"Does the resource exist?" This is the starting block for any geothermal venture, simply because you need to identify a geothermal resource and its characteristics before you can develop it.

What is the geology of the area?

- Geologic structure of the area
- Stratigraphic column and cross sections
- Are any local well logs available?
- Is seismic information available?
- Is a chemical analysis of the fluids available?

Does the geothermal resource exist?

- Where, at what depth, in what formation?
- What is the temperature, pressure, formation thickness, and flow rate of the resource?
- What is the estimated size and producing potential of the formation?
- Do you expect natural gas to be saturated in brine? If so what is the gas/brine ratio?
- Is it saturated, super saturated? What portion of the gas do you expect to extract?

Are there geological risks involved?

- Seismic, karsting, fault, or other geologic factors that may present a risk to wells and production.
- What is the produced water chemistry, i.e., amount of total dissolved solids, pH, mineral content?
- What is the likelihood of cooling the formation?
- Would field "rotation" help to mitigate cooling?

Is the resource sustainable long term?

- Does the resource replenish itself naturally, or is injection into the original formation necessary?
- Where should an injection well be located as to not thermally impact the reservoir?
- How long is the reservoir expected to sustain production rates, 10, 20, 30, 100 years?

Where will the produced fluids be dispensed?

- Into what ground formation?
- At what depth will the fluid be reinjected?
- What is the chemistry of the formation that is being injected into?
- What is the risk posed by production fluid chemistry?
- What's the size of the disposing formation?
- Are there geological risks related to disposing into this formation?
- Can the spent fluids be used for secondary recovery?

Will coproduction of hydrocarbons and geothermal fluids from the same well occur?

- Is there oil, gas, or both in the production formation?

Legal Investigation

"Can the resource be legally harnessed?" Legal issues often become some of the greatest obstacles in the development of many geothermal ventures. A thorough legal analysis will clearly identify potential issues with the site, amount of power produced, or other issues that could pose serious threats to the project. In the United States, the highest quality geothermal fields, such as in Yellowstone, are closed to all development.

What are the governing bodies of the area?

- Federal, State, Local
- Geologic (Ex. Texas Railroad Commission)
- Environmental (Ex. EPA)
- Utility companies?
- Lobbyists, etc.

Is the resource in an area approved for development?

- What state, county, city permits are needed?
- Can you drill/inject in this area?
- What zoning laws exist that threaten the project? Noise bans, visible emission bans, aesthetic rules and regulations?
- What protocols are required in order to legally produce and sell power in your area?
- What is the interconnectivity charge to load your power onto the grid?

How do you get the rights to the resource?

- It is important to note that in the state of Texas geothermal waters are considered a "mineral" and are subject to Texas mineral laws.
- Who owns the mineral rights?
- Who owns the surface land rights?
- How much will it cost to get the rights?

What environmental rules exist that could benefit/ threaten your project?

- Do any tax credits, stimulus packages, or other incentives exist that could benefit your project?
- What environmental protocols exist regarding drilling and fluid reinjection?
- What environmental protocols exist regarding emissions? (Note: Texas' geothermal resources are most efficiently harnessed by binary power plants, which give off no emissions.)

What hydrocarbon rules exist that could impact your project?

- Are there any tax benefits from producing both hydrocarbons and geothermal energy from the same well site? (Such as the Texas House Bill 4433, Severance Tax Exemption.)

Engineering Investigation

"Can the resource be efficiently harnessed?" Once the geologic resource is well understood, it becomes essential to find the most efficient way of harnessing its full potential in order to maximize plant output as well as financial gain.

What type of plant design is best suited for harnessing the resource?

- Dry steam, flash steam, or binary plant?
- Will the temperature, pressure, and fluid flow rate of my reservoir be able to support one of these plants?
- Can absorption chillers or other renewable energy types be incorporated?
- What diameter wells/ pipes do I need to produce my desired amount of energy?
- How many wells do I need to obtain my desired fluid flow rate to maximize power plant output?
- What insulation is needed in order to most efficiently transport the heat?
- What material should my casing/ pipes be made of to avoid corrosion, scaling, or other impurity related issues?

To what extent is reservoir engineering required in your resource?

- Do you need to fracture the formation in order to increase production?
- Does your reservoir require fluid injection such as an enhanced geothermal system (EGS)?

What working fluids will be involved in the plant operations?

- What refrigerants will be using in the binary systems?
- How much cooling fluid is neede and where will it come from?
- In the wells, pipes, and plant systems, what chemicals will be used to eliminate issues of scaling?

What will be required to run the plant?

- What electrical, computer, etc. systems are required in order to run the plant at its highest efficiency?
- What personnel will be needed to run the plant?
- What backup/ emergency systems will be installed in the case of a malfunction?
- What parameters will be collected on a regular basis?

How will the energy be transported from the plant to the desired market?

- What infrastructure is available to do this?
- Where is the closest utility transfer station?

Financial Investigation

"Can the project be financed?" Answering this question will be the true make or break of any business venture. If the numbers don't make sense, then the project won't make sense. Even in the case of green energy projects, there is no exception.

Opportunity Analysis

- Who will purchase the geothermal energy?
- What is the most profitable target market for your power generation— selling to the grid, distributed energy, coproduction, a combination of each?
- If gas is produced, will it be sold to a pipeline, used in a fuel cell, or in a turbine?
- How much energy is needed to satisfy the site demand?
- What are the resources already available?
- How can profits be maximizes from these resources?
- Can a Power Purchase Agreement be secured? At what price, for how many years?
- Who is the competition?
- What is the price to beat of the competitor?
- How will this project be financed (debt/equity)?
- What is the source of capital?
- What is the cost of capital?
- What financial risks are associated with the project?
- Was a Strengths, Weaknesses, Opportunities, and Threats (SWOT) Analysis completed?
- What is the anticipated performance of the plant?

Note, that for coproduced systems these questions need to be addressed for both the geothermal and hydrocarbon production.

Profit Analysis

- What is the estimated Cost of Capital ?
- Where will the project funding come from?
- What is the Net Present Value for the Project?
- What is the Future Value of the investment?
- What is the Required Rate of Return for the project?
- What discount rate is being used for risk?
- How many years does the project need to be in production to produce the required rate of return?
- How dependent are the estimates based on commodity prices??
- What is the effect of raising or lowering commodity prices?
- Are there government incentives or subsidies that may affect the outcome of these calculations?
- What is the potential for gains from "cap and trade"/ carbon-credit earnings for this project?
- If a coproduction site, what are the earnings from hydrocarbons?
- What are the expected gross and net profit from the project?
- What is the timeline for the project?
- What are the risks associated with not being on schedule? Expenses, legal ramifications, etc.
- Given the calculations, the expected budget, and the potential payback, does the project make financial sense?

Cost Analysis

What are the Exploration Cost?

- Seismic surveys, well logging and data, geologic analysis and flow tests, chemical analysis of geothermal fluids, etc.
- What are the drilling costs (drill rig, well fracturing, personnel, casing, etc.)?
- Is it possible to recomplete an existing well?
- What is the cost to recomplete a well?
- What is the estimated lifespan of a well?
- Production well (new): drilling costs, casing costs, emplacement of the wellhead, preparing the site for power plant installation.
- Production well (existing): work-over costs of well, perforation of casing, formation fracturing.
- Where will the injection well be located, designed and drilled to necessary depth, casing, injection pump, etc.?
- What are the development costs for infrastructure on and off site?

What are the Legal Costs?

- Legal costs associated with zoning, siting, drilling permits and mineral right procurement.
- Legal costs associated with rules and regulations of how to properly case and prepare a well for production use.
- What are the permitting costs and procedures? In Texas see Oil & Gas Permits from the Rail Road Commission http://www.rrc.state.tx.us/licenses/og/index.php

What are the Development Costs?

- Purchase (or design and manufacturing) of the power plant, shipping, and installment costs.
- Connection of pipes to other necessary infrastructure to the plant (separator, injection well, rock muffler, etc.).
- What are the installation costs related to equipment, transmission wires and cables, cost of machinery, and personnel to install and test run the plant.
- If connection to gas pipeline, will the gas need to be cleaned or pressurized to meet pipeline requirements.
- What are the production costs?
- Taxes and interconnection tariffs?
- What are the operation and maintenance costs associated with running the plant (cost of day-to-day plant operation, obtaining personnel etc.?
- Costs of routine yearly maintenance and monitoring, chemicals for injection to prevent scaling and corrosion?
- What is the total budget for fully developing the resource, completing project, and running it for a specific time frame?

Geothermal Agencies and Business Contacts for Texas

Organizations Assisting Renewable Energy Development

Geothermal Energy Association
Karl Gawell
209 Pennsylvania Ave., SE
Washington, D.C. 20003
karl@geo-energy.org
www.geo-energy.org
P: 202-454-5264

Geothermal Resources Council
Curt Robinson
P.O. Box 1350
Davis, CA 95617
grc@geothermal.org
www.geothermal.org
P: 530-758-2360

Research Partnership to Secure Energy for America (RPSEA)
Michael Ming
1650 Highway 6, Suite 300
Sugar Land, TX 77478
mming@rpsea.org
www.rpsea.org
P: 281-313-9555

Texas Renewables Energy Industries Association (TREIA)
Russell Smith
P.O. Box 16469
Austin, TX 78761
rsmith@treia.org
www.treia.org
P: 512-345-6469

Texas Renewable Energy Education Consortium (TREEC)
Sidney Bolfing
3801 Campus Drive
Waco, TX 76705
sidney.bolfing@tstc.edu
www.treec.org
P: 254-867-3206

Federal and State Agencies Assisting Renewable Development

Department of Energy Geothermal Technologies
Office of Energy Efficiency and Renewable Energy
Tim Reinhardt
timothy.reinhardt@ee.doe.gov
www1.eere.energy.gov/geothermal/
P: 202-287-1351

Texas State Energy Conservation Office (SECO)
Dub Taylor
LBJ State Office Building
111 East 17th St., Room 114
Austin, TX 78701
dubtaylor@cpa.state.tx.us
www.infinitepower.com
P: 512-463-1931

Texas Railroad Commission
1701 N. Congress
P.O. Box 12967
Austin, TX 78711
http://www.rrc.state.tx.us/about/divisions/index.php
http://www.rrc.state.tx.us/contact/RRCphonedirectory.pdf

Drilling Permits for Oil/Gas wells
Lorenzo Garzo
P: 512-463-6751
drillingpermits-info@rrc.state.tx.us

Injection Well Permits
Doug Johnson
P: 512-463-6792
ac@tceq.state.tx.us

TX General Land Office - Mineral Leasing
Peter Boone
1700 North Congress Avenue, Suite 600
Austin, TX 78701
peter.boone@glo.state.tx.us
www.glo.state.tx.us/
P: 512-475-1501

Rural Alliance of Renewable Energy (RARE)
Travis Brown
1700 N. Congress Ave. Suite 22
Austin, TX 78701
tbrown@orca.state.us
www.infinitepower.com/rare
P: 512-936-7878

Companies with Low Temperature Technology Geothermal Power Plants

Pratt & Whitney Power Systems
Michael Ronzello
400 Main Street
East Hartford, CT 06108
michael.ronzello@pw.utc.com
www.pw.utc.com
P: 860-727-2465

Gulf Coast Green Energy
Loy Sneary
2200 Avenue A, Suite 103
Bay City, TX 77414
loys@sbcglobal.net
www.gulfcoastgreenenergy.com
www.electratherm.com
P: 888-448-2112

ORMAT Technologies, Inc.
Josh Nordquist
6225 Neil Road
Reno, NV 89511
jnordquist@ormat.com
www.ormat.com
P: 775-356-9029

Turbine Air Systems
Halley Dickey
6110 Cullen Blvd.
Houston, TX 77021
HDickey@TAS.com
www.TAS.com
P: 713-877-8700

Cryostar USA
Tim Ryan
5909 West Loop South, Suite 220
Bellaire 77401, TX
Tim.Ryan@cryostar.com
www.cryostar.com
P: 713-661-6000

Deluge, Inc.
Brian Hageman
8765 E. Bell Road, Suite 210
Scottsdale, AZ 85260
bhageman@delugeinc.com
www.delugeinc.com
P: 602-431-0566

Linear Power Ltd.
Robert Hunt
6082 Espy Avenue
Long Beach, MS 39560
hunt0972@bellsouth.net
http://renewableone.com/linearpower
228-363-0736

Engineering Power Plants

Power Engineers
Kevin Wallace
3940 Glenbrook Drive
P.O. Box 1066
Hailey, ID 83333
www.powereng.com
P: 208-788-3456

CH2M Hill
Richard Campbell
9191 South Jamaica Street
Englewood, CO 80112
richard.campbell@ch2m.com
P: 888.242.6445
http://www.ch2m.com/

Telios Corporation
Shannon McCall
3535 Travis St., Suite 115
Dallas, TX 75204
smccall@teliospc.com
www.teliospc.com
P: 214-774-6199

Condenser- Cooling Towers

Tranter
Jody Stonecipher
P.O. Box 2289
Wichita Falls, TX 76307
jstonecipher@tranter.com
www.tranter.com
P: 940-264-1034

Dry Coolers Inc.
Bob Antaya
3232 Adventure Lane
Oxford, MI 48371
bob@drycoolers.com
www.drycoolers.com
P: 800-535-8173

Reservoir Engineering

GeothermEX Inc.
Subir Sanyal
3260 Blume Drive, Suite 220
Richmond, CA 94806
mw@geothermex.com
www.geothermex.com
P: 510-527-9876

Blade Energy Partners
Sriram Vasantharajan
2600 Network Blvd Suite 550
Frisco, TX 75034
sriramv@blade-energy.com
www.blade-energy.com
P. 972-712-8407

Consultants

Good Company Associates
Robert King
816 Congress Avenue, St 1400
Austin, TX 78701
rking@goodcompanyassociates.com
www.goodcompanyassociates.com
512-279-0751

Erdlac Energy Consulting
Richard Erdlac
4900 Thomason Drive
Midland, TX 79703
rcerdlac@cleansed.net
P: 432-69-5288

Geologic Data

UT Bureau of Economic Geology
Daniel Ortuna
Well Log Library
10100 Burnet Road
Austin, TX 78758
daniel.ortuno@beg.utexas.edu
P: 512-471-7139
http://www.beg.utexas.edu

IHS Energy
888-645-3282 or 713-840-8282
http://energy.ihs.com/index.htm

Drillinginfo, Inc.
Sales: 888-477-7667 ext. 1
sales@drilinginfo.com
http://www.info.drillinginfo.com

For more contacts and discussion of materials

Geothermal Energy Association
Membership list www.geo-energy.org

Geothermal Resources Council
www.geothermal.org/roster.html

SMU Geothermal Laboratory
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3225 Daniel Ave. Room 235
Dallas, TX 75275-0395
blackwel@smu.edu mrichard@smu.edu
www.smu.edu/geothermal
P: 214-768-2745 or 214-768-1975

SMU | GEOTHERMAL LABORATORY

APPENDIX

VII-2 CRC Handbook of Chemistry and Physics

Handbook
OF
Chemistry and Physics

A Ready-Reference Book of Chemical and Physical Data

HANDBOOK OF CHEMISTRY AND PHYSICS
1976-1977
57th
EDITION
CRC PRESS, INC.

EDITOR

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In collaboration with a large number of professional chemists and physicists whose assistance is acknowledged in the list of general collaborators and in connection with the particular tables or sections involved.

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69 SODIUM BROMIDE, NaBr—(Continued)

A % by wt.	ρ D_4^{20}	D_{20}^{20}	C_s g/l	M g-mol/l	C_w g/l	$(C_w - C_s)$ g/l	$(n - n_0) \times 10^4$	n	Δ °C	O Os/kg	S g-mol/l	η/η_0	η/ρ cS	φ rhe	γ mmho/cm	T g-mol/l
24.00	1.2163	1.2184	291.9	2.837	924.4	73.9	378	1.3708				1.242	1.023	80.37	185.0	3.21
26.00	1.2382	1.2404	321.9	3.128	916.2	82.0	415	1.3745				1.284	1.039	77.75	197.0	3.60
28.00	1.2608	1.2630	353.0	3.430	907.8	90.5	453	1.3783				1.333	1.059	74.88	207.0	4.03
30.00	1.2842	1.2864	385.2	3.744	889.9	99.3	492	1.3822				1.392	1.086	71.70	216.0	4.50
32.00	1.3083	1.3106	418.7	4.068	889.7	108.6	532	1.3862				1.462	1.120	68.26		
34.00	1.3333	1.3357	453.3	4.405	880.0	118.2	573	1.3903				1.543	1.160	64.68		
36.00	1.3592	1.3616	489.3	4.755	869.9	128.3	616	1.3946				1.636	1.206	61.01		
38.00	1.3860	1.3885	526.7	5.118	859.3	138.9	660	1.3990				1.742	1.259	57.30		
40.00	1.4138	1.4163	565.5	5.495	848.3	150.0	705	1.4035				1.862	1.320	53.60		

70 SODIUM CARBONATE, $Na_2CO_3 \cdot 10H_2O$

MOLECULAR WEIGHT = 106.00 FORMULA WEIGHT, HYDRATE = 286.16
RELATIVE SPECIFIC REFRACTIVITY = 0.619

0.00 % by wt. data are the same for all compounds.
For Values of 0.00 wt. % solutions see Table 1, Acetic Acid.

A % by wt.	H % by wt.	ρ D_4^{20}	D_{20}^{20}	C_s g/l	M g-mol/l	C_w g/l	$(C_w - C_s)$ g/l	$(n - n_0) \times 10^4$	n	Δ °C	O Os/kg	S g-mol/l	η/η_0	η/ρ cS	φ rhe	γ mmho/cm	T g-mol/l
0.50	1.35	1.0034	1.0052	5.0	0.047	998.4	−0.2	11	1.3341	0.222	0.119	0.063	1.023	1.021	97.58	7.0	0.072
1.00	2.70	1.0086	1.0104	10.1	0.095	998.5	−0.3	23	1.3352	0.425	0.229	0.123	1.047	1.040	95.32	13.1	0.139
1.50	4.05	1.0138	1.0156	15.2	0.143	998.6	−0.4	34	1.3364	0.598	0.322	0.174	1.073	1.060	93.03	18.4	0.201
2.00	5.40	1.0190	1.0208	20.4	0.192	998.6	−0.4	45	1.3375	0.751	0.404	0.219	1.100	1.082	90.73	23.3	0.260
2.50	6.75	1.0242	1.0260	25.6	0.242	998.6	−0.4	56	1.3386	0.915	0.492	0.267	1.128	1.104	88.46	27.8	0.316
3.00	8.10	1.0294	1.0312	30.9	0.291	998.5	−0.3	67	1.3397	1.082	0.582	0.316	1.157	1.127	86.23	32.0	0.369
3.50	9.45	1.0346	1.0364	36.2	0.342	998.4	−0.2	78	1.3408	1.250	0.672	0.365	1.188	1.150	84.06	36.0	0.420
4.00	10.80	1.0398	1.0416	41.6	0.392	998.2	0.0	89	1.3419	1.421	0.764	0.416	1.220	1.176	81.81	39.8	0.468
4.50	12.15	1.0450	1.0468	47.0	0.444	998.0	0.3	100	1.3430	1.593	0.857	0.466	1.253	1.202	79.62	43.5	0.515
5.00	13.50	1.0502	1.0521	52.5	0.495	997.7	0.5	110	1.3440	1.768	0.951	0.517	1.289	1.230	77.42	47.0	0.562
5.50	14.85	1.0554	1.0573	58.0	0.548	997.3	0.9	121	1.3451	1.945	1.046	0.569	1.326	1.259	75.26	50.4	0.608
6.00	16.20	1.0606	1.0625	63.6	0.600	997.0	1.3	132	1.3462	2.125	1.142	0.621	1.364	1.289	73.16	53.6	0.652
6.50	17.55	1.0658	1.0677	69.3	0.654	996.5	1.7	142	1.3472				1.404	1.320	71.09	56.7	0.694
7.00	18.90	1.0711	1.0730	75.0	0.707	996.1	2.1	153	1.3483				1.445	1.352	69.05	59.7	0.735
7.50	20.25	1.0763	1.0782	80.7	0.762	995.6	2.6	164	1.3494				1.489	1.386	67.04	62.4	0.774
8.00	21.60	1.0816	1.0835	86.5	0.816	995.1	3.1	174	1.3504				1.535	1.422	65.03	65.1	0.812
8.50	22.95	1.0869	1.0888	92.4	0.872	994.5	3.7	185	1.3515				1.583	1.460	63.03	67.6	0.848
9.00	24.30	1.0922	1.0942	98.3	0.927	993.9	4.3	196	1.3525				1.635	1.500	61.03	70.0	0.883
9.50	25.65	1.0975	1.0995	104.3	0.984	993.3	5.0	206	1.3536				1.691	1.543	59.03	72.2	0.916
10.00	27.00	1.1029	1.1048	110.3	1.040	992.6	5.6	217	1.3547				1.750	1.590	57.03	74.4	0.948
11.00	29.70	1.1136	1.1156	122.5	1.156	991.1	7.1	238	1.3568				1.880	1.691	53.09	78.3	1.00
12.00	32.40	1.1244	1.1264	134.9	1.273	989.5	8.8	259	1.3589				2.024	1.803	49.32	81.7	1.05
13.00	35.10	1.1353	1.1373	147.6	1.392	987.7	10.5	280	1.3610				2.182	1.926	45.74	84.6	1.10
14.00	37.79	1.1463	1.1483	160.5	1.514	985.8	12.4	301	1.3631				2.356	2.059	42.36	86.9	1.14
15.00	40.49	1.1574	1.1595	173.6	1.638	983.8	14.4	322	1.3652				2.546	2.204	39.20	88.6	1.16

71 SODIUM CHLORIDE, NaCl

MOLECULAR WEIGHT = 58.44
RELATIVE SPECIFIC REFRACTIVITY = 0.794

0.00 % by wt. data are the same for all compounds.
For Values of 0.00 wt. % solutions see Table 1, Acetic Acid.

A % by wt.	ρ D_4^{20}	D_{20}^{20}	C_s g/l	M g-mol/l	C_w g/l	$(C_w - C_s)$ g/l	$(n - n_0) \times 10^4$	n	Δ °C	O Os/kg	S g-mol/l	η/η_0	η/ρ cS	φ rhe	γ mmho/cm	T g-mol/l
0.10	0.9989	1.0007	1.0	0.017	997.9	0.3	2	1.3332	0.062	0.033	0.017	1.002	1.005	99.61	1.7	0.017
0.20	0.9997	1.0014	2.0	0.034	997.7	0.6	4	1.3333	0.121	0.065	0.034	1.004	1.006	99.43	3.3	0.034
0.30	1.0004	1.0021	3.0	0.051	997.4	0.9	5	1.3335	0.181	0.097	0.051	1.006	1.007	99.24	5.0	0.051
0.40	1.0011	1.0028	4.0	0.069	997.1	1.2	7	1.3337	0.240	0.129	0.069	1.007	1.008	99.06	6.6	0.069
0.50	1.0018	1.0036	5.0	0.086	996.8	1.5	9	1.3339	0.299	0.161	0.086	1.009	1.009	98.89	8.2	0.086
0.60	1.0025	1.0043	6.0	0.103	996.5	1.8	11	1.3340	0.358	0.192	0.103	1.011	1.011	98.71	9.8	0.103
0.70	1.0032	1.0050	7.0	0.120	996.2	2.1	12	1.3342	0.417	0.224	0.120	1.013	1.012	98.54	11.4	0.120
0.80	1.0039	1.0057	8.0	0.137	995.9	2.4	14	1.3344	0.475	0.256	0.137	1.015	1.013	98.37	12.9	0.137
0.90	1.0046	1.0064	9.0	0.155	995.6	2.7	16	1.3346	0.534	0.287	0.155	1.016	1.014	98.20	14.4	0.155
1.00	1.0053	1.0071	10.1	0.172	995.3	3.0	18	1.3347	0.593	0.319	0.172	1.018	1.015	98.04	16.0	0.172
1.10	1.0060	1.0078	11.1	0.189	995.0	3.3	19	1.3349	0.652	0.351	0.189	1.020	1.016	97.87	17.5	0.189
1.20	1.0068	1.0085	12.1	0.207	994.7	3.6	21	1.3351	0.711	0.382	0.207	1.021	1.017	97.72	18.9	0.207
1.30	1.0075	1.0093	13.1	0.224	994.4	3.9	23	1.3353	0.770	0.414	0.224	1.023	1.017	97.56	20.4	0.224
1.40	1.0082	1.0100	14.1	0.241	994.1	4.2	25	1.3354	0.829	0.446	0.241	1.025	1.018	97.41	21.8	0.241
1.50	1.0089	1.0107	15.1	0.259	993.8	4.5	26	1.3356	0.888	0.478	0.259	1.026	1.019	97.26	23.2	0.259
1.60	1.0096	1.0114	16.2	0.276	993.5	4.8	28	1.3358	0.948	0.509	0.276	1.028	1.020	97.11	24.6	0.276
1.70	1.0103	1.0121	17.2	0.294	993.1	5.1	30	1.3360	1.007	0.541	0.294	1.029	1.021	96.96	26.0	0.294
1.80	1.0110	1.0128	18.2	0.311	992.8	5.4	32	1.3362	1.067	0.573	0.311	1.031	1.022	96.82	27.4	0.311
1.90	1.0117	1.0135	19.2	0.329	992.5	5.7	33	1.3363	1.126	0.605	0.329	1.032	1.022	96.67	28.8	0.329
2.00	1.0125	1.0143	20.2	0.346	992.2	6.0	35	1.3365	1.186	0.638	0.346	1.034	1.023	96.52	30.2	0.346
2.10	1.0132	1.0150	21.3	0.364	991.9	6.3	37	1.3367	1.246	0.670	0.364	1.036	1.024	96.37	31.6	0.364
2.20	1.0139	1.0157	22.3	0.382	991.6	6.6	39	1.3369	1.306	0.702	0.382	1.037	1.025	96.22	33.0	0.382
2.30	1.0146	1.0164	23.3	0.399	991.3	7.0	40	1.3370	1.366	0.734	0.399	1.039	1.026	96.07	34.3	0.399
2.40	1.0153	1.0171	24.4	0.418	991.0	7.3	42	1.3372	1.426	0.767	0.418	1.040	1.027	95.93	35.7	0.418
2.50	1.0160	1.0178	25.4	0.435	990.6	7.6	44	1.3374	1.486	0.799	0.435	1.042	1.028	95.78	37.1	0.435
2.60	1.0168	1.0185	26.4	0.452	990.3	7.9	46	1.3376	1.547	0.832	0.452	1.044	1.028	95.64	38.5	0.452
2.70	1.0175	1.0193	27.5	0.470	990.0	8.2	47	1.3377	1.607	0.864	0.470	1.045	1.029	95.49	39.9	0.470
2.80	1.0182	1.0200	28.5	0.488	989.7	8.6	49	1.3379	1.668	0.897	0.488	1.047	1.030	95.35	41.2	0.488
2.90	1.0189	1.0207	29.5	0.505	989.4	8.9	51	1.3381	1.729	0.930	0.505	1.048	1.031	95.21	42.6	0.505
3.00	1.0196	1.0214	30.6	0.523	989.0	9.2	53	1.3383	1.790	0.962	0.523	1.050	1.032	95.06	44.0	0.523
3.10	1.0203	1.0221	31.6	0.541	988.7	9.5	54	1.3384	1.851	0.995	0.541	1.051	1.033	94.92	45.3	0.541
3.20	1.0211	1.0229	32.7	0.559	988.4	9.9	56	1.3386	1.913	1.028	0.559	1.053	1.033	94.78	46.7	0.559

71 SODIUM CHLORIDE, NaCl—(Continued)

A %, by wt.	ρ D_4^{20}	D_4^{25}	C_s g/l	M g-mol/l	C_w g/l	$(C_s - C_w)$ g/l	$(n - n_w) \times 10^4$	n	Δ °C	O Osi/kg	S g-mol/l	η/η_w	η/ρ cS	ϕ rhe	γ mmho/cm	T g-mol/l
3.30	1.0218	1.0236	33.7	0.577	988.0	10.2	58	1.3388	1.974	1.061	0.577	1.055	1.034	94.64	48.0	0.577
3.40	1.0225	1.0243	34.8	0.595	987.7	10.5	60	1.3390	2.036	1.094	0.595	1.056	1.035	94.50	49.4	0.595
3.50	1.0232	1.0250	35.8	0.613	987.4	10.8	61	1.3391	2.098	1.128	0.613	1.058	1.036	94.35	50.7	0.613
3.60	1.0239	1.0257	36.9	0.631	987.1	11.2	63	1.3393	2.160	1.161	0.631	1.059	1.037	94.21	52.0	0.631
3.70	1.0246	1.0265	37.9	0.649	986.7	11.5	65	1.3395	2.222	1.194	0.649	1.061	1.037	94.07	53.3	0.649
3.80	1.0254	1.0272	39.0	0.667	986.4	11.8	67	1.3397	2.284	1.228	0.667	1.063	1.038	93.93	54.7	0.667
3.90	1.0261	1.0279	40.0	0.685	986.1	12.2	68	1.3398	2.347	1.262	0.685	1.064	1.039	93.78	56.0	0.685
4.00	1.0268	1.0286	41.1	0.703	985.7	12.5	70	1.3400	2.409	1.295	0.703	1.066	1.040	93.64	57.3	0.703
4.10	1.0275	1.0293	42.1	0.721	985.4	12.8	72	1.3402	2.472	1.329	0.721	1.067	1.041	93.49	58.6	0.721
4.20	1.0282	1.0301	43.2	0.739	985.1	13.2	74	1.3404	2.535	1.363	0.739	1.069	1.042	93.35	59.9	0.739
4.30	1.0290	1.0308	44.2	0.757	984.7	13.5	75	1.3405	2.598	1.397	0.757	1.071	1.043	93.20	61.2	0.757
4.40	1.0297	1.0315	45.3	0.775	984.4	13.9	77	1.3407	2.662	1.431	0.775	1.072	1.044	93.06	62.5	0.775
4.50	1.0304	1.0322	46.4	0.794	984.0	14.2	79	1.3409	2.725	1.465	0.794	1.074	1.045	92.91	63.8	0.794
4.60	1.0311	1.0330	47.4	0.812	983.7	14.5	81	1.3411	2.789	1.500	0.812	1.076	1.046	92.76	65.1	0.812
4.70	1.0318	1.0337	48.5	0.830	983.4	14.9	82	1.3412	2.853	1.534	0.830	1.078	1.046	92.61	66.3	0.830
4.80	1.0326	1.0344	49.6	0.848	983.0	15.2	84	1.3414	2.917	1.569	0.848	1.079	1.047	92.46	67.6	0.848
4.90	1.0333	1.0351	50.6	0.866	982.7	15.6	86	1.3416	2.982	1.603	0.866	1.081	1.048	92.31	68.9	0.866
5.00	1.0340	1.0358	51.7	0.885	982.3	15.9	88	1.3418	3.046	1.638	0.885	1.083	1.049	92.15	70.1	0.885
5.20	1.0355	1.0373	53.8	0.921	981.6	16.6	91	1.3421	3.176	1.708	0.921	1.087	1.052	91.84	72.6	0.921
5.40	1.0369	1.0387	56.0	0.958	980.9	17.3	95	1.3425	3.307	1.778	0.958	1.090	1.054	91.53	75.1	0.958
5.60	1.0384	1.0402	58.1	0.995	980.2	18.0	98	1.3428	3.438	1.848	0.995	1.094	1.056	91.22	77.5	0.995
5.80	1.0398	1.0417	60.3	1.032	979.5	18.7	102	1.3432	3.570	1.919	1.032	1.098	1.058	90.90	80.0	1.032
6.00	1.0413	1.0431	62.5	1.069	978.8	19.4	105	1.3435	3.703	1.991	1.069	1.102	1.060	90.59	82.4	1.069
6.20	1.0427	1.0446	64.6	1.106	978.1	20.2	109	1.3439	3.837	2.063	1.106	1.106	1.062	90.27	84.7	1.106
6.40	1.0442	1.0460	66.8	1.144	977.4	20.9	112	1.3442	3.972	2.135	1.144	1.109	1.065	89.95	87.1	1.144
6.60	1.0456	1.0475	69.0	1.181	976.6	21.6	116	1.3446	4.107	2.208	1.181	1.113	1.067	89.63	89.4	1.181
6.80	1.0471	1.0490	71.2	1.218	975.9	22.3	119	1.3449	4.244	2.282	1.218	1.117	1.069	89.31	91.8	1.218
7.00	1.0486	1.0504	73.4	1.256	975.2	23.1	123	1.3453	4.378	2.354	1.256	1.122	1.072	88.99	94.1	1.256
7.20	1.0500	1.0519	75.6	1.294	974.4	23.8	126	1.3456	4.516	2.428	1.294	1.126	1.074	88.66	96.4	1.294
7.40	1.0515	1.0533	77.8	1.331	973.7	24.6	130	1.3460	4.655	2.503	1.331	1.130	1.077	88.33	98.7	1.331
7.60	1.0530	1.0548	80.0	1.369	972.9	25.3	133	1.3463	4.795	2.578	1.369	1.134	1.079	88.00	101.	1.369
7.80	1.0544	1.0563	82.2	1.407	972.2	26.1	137	1.3467	4.937	2.654	1.407	1.138	1.082	87.67	103.	1.407
8.00	1.0559	1.0578	84.5	1.445	971.4	26.8	140	1.3470	5.079	2.731	1.445	1.143	1.084	87.33	105.	1.445
8.20	1.0574	1.0592	86.7	1.484	970.7	27.6	144	1.3474	5.222	2.808	1.484	1.147	1.087	86.99	107.	1.484
8.40	1.0588	1.0607	88.9	1.522	969.9	28.3	147	1.3477	5.367	2.885	1.522	1.152	1.090	86.65	109.	1.522
8.60	1.0603	1.0622	91.2	1.560	969.1	29.1	151	1.3481	5.512	2.964	1.560	1.156	1.093	86.30	112.	1.560
8.80	1.0618	1.0637	93.4	1.599	968.3	29.9	154	1.3484	5.659	3.043	1.599	1.161	1.096	85.95	114.	1.599
9.00	1.0633	1.0651	95.7	1.637	967.6	30.7	158	1.3488	5.807	3.122	1.637	1.166	1.099	85.60	116.	1.637
9.20	1.0647	1.0666	98.0	1.676	966.8	31.4	161	1.3491	5.956	3.202	1.676	1.171	1.102	85.25	118.	1.676
9.40	1.0662	1.0681	100.2	1.715	966.0	32.2	165	1.3495	6.106	3.283	1.715	1.176	1.105	84.89	120.	1.715
9.60	1.0677	1.0696	102.5	1.754	965.2	33.0	168	1.3498	6.258	3.364	1.754	1.181	1.108	84.53	122.	1.754
9.80	1.0692	1.0711	104.8	1.793	964.4	33.8	172	1.3502	6.410	3.446	1.793	1.186	1.111	84.16	124.	1.793
10.00	1.0707	1.0726	107.1	1.832	963.6	34.6	175	1.3505	6.564	3.529	1.832	1.191	1.115	83.80	126.	1.832
10.50	1.0744	1.0763	112.8	1.930	961.6	36.6	184	1.3514	6.954	3.739	1.930	1.204	1.123	82.86	131.	1.930
11.00	1.0781	1.0801	118.6	2.029	959.5	38.7	193	1.3523	7.353	3.953	2.029	1.218	1.132	81.90	136.	2.029
11.50	1.0819	1.0838	124.4	2.129	957.5	40.8	202	1.3532	7.760	4.172	2.129	1.233	1.142	80.94	140.	2.129
12.00	1.0857	1.0876	130.3	2.229	955.4	42.9	211	1.3541	8.176	4.396	2.229	1.248	1.152	79.95	145.	2.229
12.50	1.0894	1.0914	136.2	2.330	953.3	45.0	220	1.3549	8.602	4.625	2.330	1.264	1.162	78.96	149.	2.330
13.00	1.0932	1.0952	142.1	2.432	951.1	47.1	228	1.3558	9.038	4.859	2.432	1.280	1.173	77.97	154.	2.432
13.50	1.0970	1.0990	148.1	2.534	948.9	49.3	237	1.3567	9.484	5.099	2.534	1.297	1.184	76.97	158.	2.534
14.00	1.1008	1.1028	154.1	2.637	946.7	51.5	246	1.3576	9.940	5.344	2.637	1.314	1.196	75.97	163.	2.637
14.50	1.1047	1.1066	160.2	2.741	944.5	53.7	255	1.3585	10.408	5.596	2.741	1.331	1.207	74.97	167.	2.741
15.00	1.1085	1.1105	166.3	2.845	942.2	56.0	264	1.3594	10.888	5.854	2.845	1.349	1.219	73.98	171.	2.845
16.00	1.1162	1.1182	178.6	3.056	937.6	60.6	282	1.3612	11.885	6.390	3.056	1.385	1.243	72.07	179.	3.056
17.00	1.1240	1.1260	191.1	3.270	932.9	65.3	300	1.3630	12.935	6.954	3.270	1.421	1.267	70.21	186.	3.270
18.00	1.1319	1.1339	203.7	3.486	928.1	70.1	318	1.3648	14.044	7.550	3.486	1.460	1.293	68.34	193.	3.486
19.00	1.1398	1.1418	216.6	3.706	923.2	75.0	336	1.3666	15.216	8.181	3.706	1.504	1.322	66.36	199.	3.705
20.00	1.1478	1.1498	229.6	3.928	918.2	80.0	354	1.3684	16.458	8.849	3.928	1.554	1.357	64.22	204.	3.928
21.00	1.1558	1.1579	242.7	4.153	913.1	85.1	372	1.3702	17.776	9.557	4.153	1.611	1.396	61.95	209.	4.153
22.00	1.1640	1.1660	256.1	4.382	907.9	90.4	391	1.3721	19.176	10.310	4.382	1.673	1.441	59.64	213.	4.382
23.00	1.1721	1.1742	269.6	4.613	902.6	95.7	409	1.3739	20.667	11.111	4.613	1.742	1.489	57.29	217.	4.613
24.00	1.1804	1.1825	283.3	4.848	897.1	101.1	428	1.3757			4.848	1.817	1.542	54.93	220.	4.848
25.00	1.1887	1.1909	297.2	5.085	891.6	106.7	446	1.3776			5.085	1.898	1.600	52.58	222.	5.085
26.00	1.1972	1.1993	311.3	5.326	885.9	112.3	465	1.3795			5.326	1.986	1.662	50.26	225.	5.326

APPENDIX

VII-3 HP-41 Water Viscosity Equations

APPENDIX VII-3

HP-41 WATER VISCOSITY EQUATIONS

WATER VISCOSITY

The UW program estimates the viscosity of reservoir brines (UW) as a function of salinity, temperature, and pressure. The program also estimates the saturation pressure of water (PSAT) as a function of temperature.

Equations:

$$UW\,(H_2O) = 241.4\,(10^{-4})\,10^{[247.8\,/\,(T'-140)]} \cdot [1 + (P' - PSAT')\,1.0467\,(10^{-6})\,(T' - 305)]$$

$$T' = T \text{ in K}$$

$$P' = P \text{ in BAR}$$

$$PSAT' = PSAT \text{ in BAR}$$

Salinity Correction:

$$UW\,(\text{brine}) = UW\,(H_2O)\,\{1 - 1.87\,(10^{-3})\,\%NACL^{0.5} + 2.18\,(10^{-4})\,\%NACL^{2.5} + (T^{0.5} - 0.0135\,T) \cdot [2.76\,(10^{-3})\,\%NACL - 3.44\,(10^{-4})\,\%NACL^{1.5}]\}$$

Saturation Pressure:

$$PSAT' = 22088 \exp\left[\frac{374.136 - T''}{T'} \sum_{i=1}^{8} A_i (0.65 - 0.01\,T'')^{i-1}\right]$$

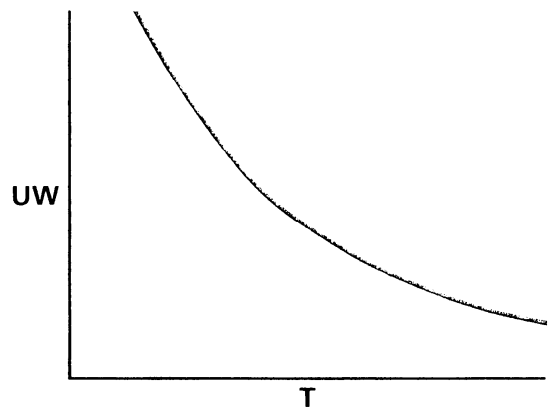
$$PSAT' = PSAT \text{ in KPA}$$

$$T' = T \text{ in K}$$

$$T'' = T \text{ in C}$$

PSAT Coefficients

i	A_i
1	−7.419242
2	−0.29721
3	−0.1155286
4	−0.008685635
5	0.001094098
6	0.00439993
7	0.002520658
8	0.0005218684



Calculation Subroutines:

There are two calculation subroutines for this program. The first subroutine is called CUW (*Calculate UW*). The routine expects certain variables (%NACL, T, P) in the proper registers (see Appendix B). Upon return, UW in CP will be in X.

The second subroutine is called CPSAT (*Calculate PSAT*). The routine expects T in X. Upon return, PSAT in PSI will be in X.

Range of Validity:

For UW:

$$32 < T < 572 \text{ F}$$
$$\text{PSAT} < P < 11600 \text{ PSI}$$
$$0 \leqslant \%\text{NACL} < 25$$

The program will halt and display ***P < PSAT*** for pressures less than the saturation pressure of water for the temperature being used. If this occurs, press [←] to see the saturation pressure. Then restart the program using either a pressure higher than PSAT or a lower temperature.

Remarks:

The saturation pressure of water is the pressure at which water will vaporize for a given temperature, and this temperature is called the saturation temperature. If the pressure is less than PSAT, a vapor phase is present, and the liquid viscosity cannot be calculated.

References:

Haywood, R. W., "Sixth International Conference on the Properties of Steam—Supplement on Transport Properties," *J. Eng. Power, Trans. ASME,* January, 1966, pp. 63-66.

Numbere, D., Brigham, W. E., and Standing, M. B., *Correlations for Physical Properties of Petroleum Reservoir Brines,* Petroleum Research Institute, Stanford University, November, 1977, p. 8.

Keenan, J. H., *et. al, Steam Tables,* John Wiley and Sons, 1969, p. 141.

Van Wylen, G. J., and Sonntag, R. E., *Fundamentals of Classical Thermodynamics,* John Wiley and Sons, 1973, pp. 40-41.

User Instructions:

SIZE: 020

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] UW	%NACL=?
2	Key in weight percent sodium chloride. If you do not know weight percent, but do know parts per million, press [R/S] to get the parts per million prompt, and then key in parts per million.	%NACL or PPM	[R/S] [R/S] [R/S]	T=? PPM=? T=?
3	Key in temperature.	T	[R/S]	P=?
4	Key in pressure and calculate UW.	P	[R/S] [R/S]*	UW=† P=?
5	For a new pressure, go to step 4. For a new case, go to step 1. Key in only values which change. For values which do not change, ignore the prompts and press [R/S]. *Press [R/S] if you are not using a printer. †Press [ALPHA] to see the units if you are not using a printer.			

Example 1:

A reservoir brine has 18 percent sodium chloride. The brine is at a temperature of 50 C and a pressure of 180 ATM. What is the viscosity of the brine in PA*S? If the pressure doubles, what is the viscosity? Turn on the output portion of the Unit Management System (set flag 10) to allow you to change the output units.

Keystrokes (SIZE >= 020)	Display	
[■] [SF] 10 [■] [ENG] 4		
[XEQ] [ALPHA] UW [ALPHA]	%NACL=?	
18 [R/S]	T=?	
50 [ALPHA] C [R/S]	P=?	
180 [ALPHA] ATM [R/S]	UW, CP?	
PA*S [R/S]	UW=825.48E-6	PA*S†
[R/S]*	P=?	
[←]	2.6453 03	

Pressing [←] shows you the previous value for P. Whenever there is an input or output prompt, the number in X always corresponds to the units shown in the ALPHA register. Check the ALPHA register to see what the units are.

[ALPHA]	PSI	

The number in X is 180 ATM converted to PSI (English default units because flag 09 is clear).

[ALPHA] 2 [×] [R/S]	UW, PA*S?	
[R/S]	UW=828.33E-6	PA*S†

Notice that the units you selected for UW, the primary output variable, were saved for you.

*Press [R/S] if you are not using a printer.

†Press [ALPHA] to see the units if you are not using a printer.

```
H2O VIS

%NACL=18.000E0
T=50.000E0 C
P=180.00E0 ATM

UW=825.48E-6 PA*S

P=5.2905E3 PSI
UW=828.33E-6 PA*S
```

For programmers who want to use Pac input and calculation subroutines in their own programs, the following examples illustrate the use of these routines. If you do not intend to use these subroutines in your programs, you should skip the next examples.

Example 2:

Assuming you have just run the last example, use the calculation subroutine to compute the viscosity in PA*S for salt-free water at the same temperature and pressure. Use the sodium chloride input routine (%NACL) to input and store the new %NACL.

Keystrokes	Display	
[XEQ] [ALPHA] %NACL [ALPHA]	*%NACL=?*	
0 [R/S]	*0.0000 00*	%NACL
[XEQ] [ALPHA] CUW [ALPHA]	*547.93 -03*	UW (CP)
[ALPHA]	*F*	

All calculation subroutines return values in Pac English default units. Because of this, the contents of the ALPHA register after executing a calculation subroutine are not related to the units of the variables that were calculated.

PA*S-CP [ALPHA]	*547.93 -03*	
[XEQ] [ALPHA] INCON [ALPHA]	*547.93 -06*	UW (PA*S)
	%NACL=0.0000E0	

Example 3:

For a temperature of 120 C, what is the saturation pressure of water in PSI? Remember that all inputs to a calculation subroutine must be in Pac English default units.

Keystrokes	Display	
120 [ALPHA] C-F [ALPHA]	*120.00 00*	T (C)
[XEQ] [ALPHA] CON [ALPHA]	*248.00 00*	T (F)
[XEQ] [ALPHA] CPSAT [ALPHA]	*28.793 00*	PSAT (PSI)
[↑] [CF] 10 [↑] [FIX] 4	*28.7929*	

APPENDIX

VII-4 Saline Water Resources Texas

APPENDIX VII-4

Saline-Water Resources of Texas

By A. G. WINSLOW *and* L. R. KISTER

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1365

One State's reserves of saline water—a potential water resource

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1956

UNITED STATES DEPARTMENT OF THE INTERIOR

Fred A. Seaton, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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SALINE-WATER RESOURCES OF TEXAS

By A. G. Winslow and L. R. Kister

ABSTRACT

Large quantities of saline water are available in the world, both on the surface and underground; however, these waters have not been studied extensively as sources of potable water.

Saline water is defined herein as water containing more than 1,000 parts per million of dissolved solids, or, with certain mineralized irrigation waters whose exact dissolved-solids content is not known, water containing more than 60 percent sodium.

Saline ground water occurs as connate water or other saline water that entered an aquifer in the geologic past and has not been flushed from the aquifer; as the result of solution of soluble materials in aquifers by percolating ground water; as a result of salt-water encroachment into aquifers which are in hydrologic connection with saline waters; or as the result of concentration by evaporation, especially in the vicinity of playa lakes.

Surface water may become saline as a result of seepage of highly mineralized ground water; solution of salts from rocks over which the streams flow; intrusion of sea water in tidal reaches of a stream; and discharge of saline wastes from industrial operations.

Most of the aquifers in Texas contain saline water in some parts, and a few are capable of producing large quantities of saline water. Of the early Paleozoic formations, the Hickory sandstone member of the Riley formation of Cambrian age and the Ellenburger group of Ordovician age are potential sources of small to moderate supplies of saline water in parts of central and west-central Texas.

Several of the Permian formations, of which the Blaine gypsum and certain limestone and dolomite strata of the Wichita and Clear Fork groups are the most important, yield varying quantities of saline water in parts of the Osage Plains region. In the Pecos Valley and trans-Pecos regions, large quantities of saline water are used from wells tapping the Rustler and Bone Spring limestones of Permian age.

Some of the aquifers of Cretaceous age are potential sources of moderate to large supplies of saline water, particularly in a belt extending from northeast Texas southwestward into south Texas, and lying roughly parallel to the Balcones fault zone on the east and south of it. The most important of these include the formations of the Trinity group, the Edwards limestone and associated limestones, and the Woodbine sand.

The Eocene strata of the West Gulf Coastal Plain include some potentially large sources of saline water. Beds of the Wilcox group, the Carrizo sand, and the Sparta sand yield moderate to large quantities of fresh water to wells and probably could yield large quantities of saline water in areas downdip from the areas that yield fresh water.

Aquifers of Miocene and Miocene(?) age that are capable of producing moderate to large quantities of saline water to wells in parts of the west Gulf Coastal Plain include the Catahoula sandstone, the Oakville sandstone, and the Lagarto clay.

Aquifers of Pliocene, Pliocene(?), and Pleistocene age on the west Gulf Coastal Plain are probably the greatest potential sources of saline water in the coastal region of Texas. The Goliad sand, Willis sand, and Lissie formation, undifferentiated, and the Beaumont clay yield moderate to large quantities of fresh water to wells along the coast. They could, no doubt, yield large quantities of saline water in a narrow belt immediately adjoining the coast where large supplies of fresh water are not available.

The Ogallala formation of Pliocene age yields saline water in the vicinity of some of the playa lakes on the High Plains.

Pleistocene and Recent alluvial deposits yield large quantities of water to wells in some places in Texas. Probably the most important of the alluvial aquifers are those of the bolson deposits in the trans-Pecos region. In the El Paso area large quantities of fresh water are pumped from the bolson deposits, and recent test drilling has shown that large quantities of saline water underlie the fresh water. Alluvial deposits in the Pecos Valley and in the lower Rio Grande valley yield large quantities of fresh water to wells and are known to be sources of large quantities of saline water in some places.

Surface water becomes saline in the lower reaches of streams that drain to the Gulf of Mexico. The salinity is increased in some places where large withdrawals of stream water cause intrusion of sea water. Disposal of oilfield brines also contributes to the salinity of certain streams from time to time.

Analyses of the Canadian River in the Texas Panhandle show the occurrence of slightly saline water during periods of low flow. However, weighted-average analyses obtained from continuous sampling show that the water is nonsaline.

Upper reaches of the Red, Brazos, and Colorado Rivers and their tributaries contain water that ranges from slightly to very saline. Impounding of floodwater on these rivers and subsequent release during periods of low flow have generally improved the chemical quality of the water in the lower reaches.

The water of the Rio Grande is moderately saline at times near the Fort Quitman and upper Presidio stations. The Falcon Dam at the Zapata-Starr County line probably will eliminate saline water in the river in the lower valley. Water from the Pecos River, tributary to the Rio Grande, ranges from slightly to moderately saline at Orla to very saline at Grandfalls.

INTRODUCTION

PURPOSE AND SCOPE

This report is a contribution to the Department of Interior's Saline Water Conversion Program for investigating feasible ways of demineralizing saline water for use in areas that have insufficient water. It is one of a group of proposed relatively detailed reports on individual States or groups of States which will be necessary to the planning of research in and development of saline-water conversion processes. General information on the occurrence of saline water in the United States will be given in a later report.

Because most processes for removing the salt from water vary in cost in proportion to the salinity of the water, information about the location of saline waters and their typical analyses will be most helpful in determining where particular processes may be technically and economically feasible.

Despite the large quantities of surface or underground saline water available almost everywhere, these waters have not been studied as sources of potable water. It is the purpose of this report to outline the occurrence, quantity, and quality of saline water available in Texas; to discuss and identify aquifers containing saline water, with emphasis on those capable of yielding large quantities; and to delineate areas in which a considerable amount of saline surface water is available. Representative analyses of water from the principal sources also are included. Texas was selected for this preliminary report because of the wide variation in use and need for water, because available information indicated that there are large quantities of saline water in Texas, and because of severe droughts and local shortages of potable water during recent years.

ACKNOWLEDGMENTS

The data on which this report is based were taken from sources in the files of the U. S. Geological Survey at Austin, Tex., from published and unpublished reports by the Texas State Board of Water Engineers prepared in cooperation with the Geological Survey, and from published reports by the Bureau of Economic Geology of the University of Texas. Other data were obtained from records of the Humble Oil and Refining Co., the Texas State Health Department, and the Works Progress Administration.

Time limitations did not permit an exhaustive study of all the possible sources of information on saline water in Texas. The U. S. Bureau of Mines and many of the oil companies have in their files much information which might be obtained if a more comprehensive study of the saline-water resources of Texas were made.

CHEMICAL ANALYSES OF WATER

Most of the chemical analyses reported here were made by the Geological Survey. Most of the analyses show the major water-soluble constituents. Concentrations of the individual constituents are expressed in parts per million (ppm), which is a measure of the weight of 1 part of dissolved substance in 1 million parts of solution.

A comprehensive discussion of the individual mineral constituents is not included in this report. However, definitions are given for specific conductance, dissolved solids, and percent sodium because they are considered to be the most important factors in classifying water as fresh or saline. Boron is discussed briefly because of its toxic effect, in comparatively low concentrations, on many plants.

Specific conductance, expressed in micromhos per centimeter at 25°C, is a measure of the ability of the ions in solution to conduct an electric current. It serves as a general indication of the amount of dissolved material in the water.

The dissolved-solids concentration, in parts per million, is the weight of dissolved material in water and is determined either as the weight of the residue upon evaporation and drying at 180°C or as the arithmetical sum of the weights of the determined constituents, the bicarbonate being computed as carbonate. The residue from some water containing more than 1,000 ppm of dissolved solids includes organic matter and water of crystallization in sufficient quantities to cause considerable variation in the reporting of dissolved solids. For this reason, most of the values for dissolved solids in the tables of analyses in this report are the sums of the individually determined constituents, but some are the weights of the residue after evaporation, particularly where insufficient determinations of individual constituents were available for computing a sum.

The percent sodium is a derived quantity obtained by dividing the equivalents per million of sodium, multiplied by 100, by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium. An excessive proportion of sodium in the water applied to land may cause the soil structure to break down and the soil to become relatively impervious to the passage of water. The percent sodium, therefore, is important to the prospective user of water for irrigation. The usefulness of irrigation water may be indicated also by the sodium-adsorption ratio, recently described by Richards and others (1954). However, percent sodium is used in this report because most available analyses are expressed thus.

According to Richards and others (1954), boron is essential to the normal growth of all plants, but the quantity required is very small. The occurrence of boron in toxic concentrations may be indicated by leaf burn, bleaching of normal plant color (chlorosis), or death of plant tissue (necrosis). Citrus, stone-fruit, and pecan trees are among the plants highly sensitive to boron in irrigation water. Lemons show definite injury when irrigated with

water containing 1 ppm of boron, but alfalfa will make maximum growth with irrigation water containing 1 to 2 ppm of boron.

The analyses of saline ground water and the descriptions of the wells sampled are given in tables 1 and 2, respectively. Similar data on quality and source of the saline surface waters are given in tables 3 and 4.

DEFINITION OF SALINE WATER

For the purpose of this report, water containing more than 1,000 ppm of dissolved solids is regarded as saline. This lower limit of dissolved solids was selected because a dissolved-solids content of as much as 1,000 ppm in water is acceptable (though 500 ppm is recommended) to the U. S. Public Health Service in potable water used by interstate carriers (U. S. Public Health Service, 1946). It must be recognized that in many areas of Texas the only available water supply may have a dissolved-solids concentration greatly in excess of 1,000 ppm. Therefore, waters discussed in this report will be classified as "slightly saline," "moderately saline," or "very saline," or as "brine," according to the following tabulation.

Description	*Dissolved solids, in parts per million*
Slightly saline	1,000 to 3,000
Moderately saline	3,000 to 10,000
Very saline	10,000 to 35,000
Brine	More than 35,000

Water used by many small communities, farms, and ranches is in the slightly saline range. Water of this class has been recognized as somewhat unsatisfactory but generally not harmful. Water containing as much as 3,000 ppm of dissolved solids generally has been considered satisfactory for irrigation, depending on other factors relating to the soil and to crop growth.

Water having a dissolved-solids content ranging from 3,000 to 10,000 ppm, herein described as moderately saline, is unsatisfactory for most purposes and is rarely used for domestic supply. Irrigation on the sandy soils of the Pecos Valley in Texas and New Mexico has been carried on with this kind of water for many years, generally with success, although some lands have been abandoned because of salinity problems resulting from irrigation. Natural drainage conditions, however, are particularly favorable in the Pecos Valley for the use of this water, whereas in most other parts of the State and Nation, where drainage conditions are

not as favorable, such water could not be used. Experiments have indicated that 10,000 ppm is about the upper limit of salinity that can be tolerated by livestock (Smith, Dott, and Warkentin, 1942, p. 15).

Water containing 10,000 to 35,000 ppm of dissolved solids is classified as very saline. The upper limit of this classification is set approximately at the concentration of sea water. Some of the aquifers in Texas yield varying amounts of water of this class. Closed lakes and basins in which the water is concentrated by evaporation are also capable of yielding supplies of very saline water. Industry has used some sea water along the coast for cooling.

Water having more than 35,000 ppm of dissolved solids is classed as brine; such water probably cannot be demineralized economically at present for general use. In addition to high costs of demineralization, there would be a problem of disposal of salt residues. Brines are used in places for repressuring oilfields, and they are a valuable source of certain minerals.

OCCURRENCE OF SALINE WATER

GROUND WATER

Many of the geologic formations which constitute the aquifers are sedimentary rocks deposited originally in saline water. Some of the saline water in the aquifers at the present time is connate (water in which the formation was deposited); some of it has entered the aquifers since they were laid down. From many formations where there are opportunities for natural discharge, the connate water has been partly or entirely flushed; however, in some formations structural or stratigraphic traps may prevent natural flushing and the saline water remains.

Most ground water is derived from precipitation on the outcrop of an aquifer or from streams that cross the outcrop. As the water percolates through the aquifer, it dissolves the soluble constituents of the rock. The Permian rocks, cropping out in the Osage Plains region and in parts of the Pecos Valley and trans-Pecos regions, include many beds of evaporites such as salt, gypsum, and anhydrite. Water percolating through these beds or running over the outcrop area may dissolve large quantities of these soluble minerals and thus become saline.

Along seacoasts or in other places where aquifers may be in hydrologic connection with saline water, encroachment may occur

as a result of a lowering of fresh-water head by drought or pumping. Such contamination by encroachment of saline water has occurred at some places along the Texas coast.

Another type of occurrence of saline ground water is that in the vicinity of playa lakes where there is discharge of ground water by evaporation and transpiration by plants. The concentration of salts in the water increases where the evapotranspiration of ground water takes place, thus causing the water to become saline.

SURFACE WATER

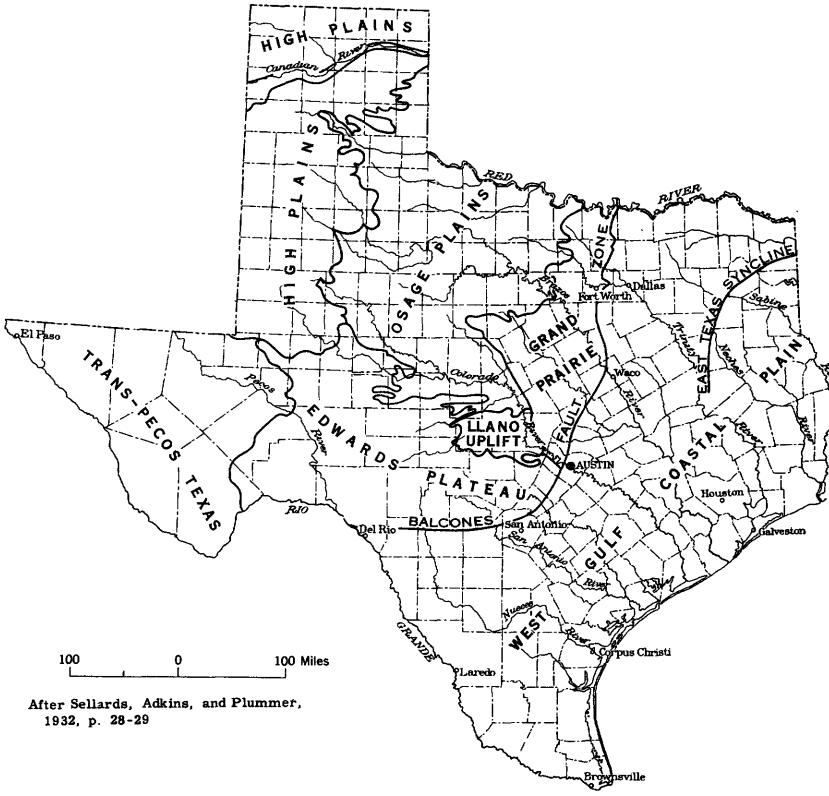
Saline surface water occurs in many of the streams in Texas; however, occurrence of saline surface water for long periods of time is limited to a few areas. The mineral content of water in the streams varies tremendously, depending on the discharge; however, the base or low flow of the streams may be of relatively uniform salinity.

Streams that originate in or pass through the outcrop area of evaporites such as those in the Osage Plains region may, at least at times, be saline; however, these same streams may become fresh in their lower reaches, after receiving fresh water from downstream tributaries. Except for those contaminated by oilfield wastes, streams originating on the West Gulf Coastal Plain are generally fresh in their upper reaches, at least, for evaporites do not occur in quantity in that area.

GENERAL GEOLOGY AND SALINE-WATER AQUIFERS

The geology of Texas presents a diversified picture both stratigraphically and structurally. Rocks ranging from Precambrian to Recent are present, and structures range from those exhibiting the effects of intense diastrophism typical of some of the Precambrian rocks in central Texas to the relatively simple homocline of the West Gulf Coastal Plain.

A comprehensive description of the geology of Texas is given by Sellards, Adkins, and Plummer (1932). Their publication has been used freely in the following geological discussion, and many of the formation descriptions have been taken from it. A general discussion of the geology of Texas perhaps should be related to the physiographic, structural, and geographic features represented in the State (fig. 1).



After Sellards, Adkins, and Plummer, 1932, p. 28-29

Figure 1.—Map showing physiographic, structural, and geographic features referred to in text.

The oldest rocks, including the Precambrian and lower Paleozoic formations, are exposed in the Llano uplift in central Texas and in places in trans-Pecos Texas. The Precambrian rocks are known to contain only small quantities of water; hence they are not considered further in this report. Some of the Cambrian and Ordovician rocks are aquifers, especially those on the flanks of the Llano uplift and at some places in trans-Pecos Texas.

The upper Paleozoic formations crop out in the Osage Plains region, where they dip generally westward. They crop out also in parts of trans-Pecos Texas. Some of these formations, particularly those of the Permian, are the sources of the salts present in much of the saline water of the State, both on the surface and underground. Thick beds of evaporites are present both in the outcrop area and in the subsurface. Ground water percolating through the beds of salt and gypsum, and surface water flowing on their

outcrops, dissolve large quantities of these relatively soluble materials, slowly removing them from the source beds.

Mesozoic formations crop out in a large area of Texas. The outcrop of the Triassic rocks, which consist mainly of sandstone and shale, is confined largely to the western edge of the Osage Plains region. These rocks disappear to the west where they are covered by the younger formations of the High Plains.

The principal outcrops of the Cretaceous rocks are in the Edwards Plateau, in the Grand Prairie region, and in a narrow belt along the west edge of the West Gulf Coastal Plain. These formations, consisting largely of sand, clay, and limestone, dip gently toward the southeast or south, where they pass beneath the Tertiary formations of the West Gulf Coastal Plain.

The largest area of outcrop of the Tertiary formations in Texas is in the West Gulf Coastal Plain, where the rocks consist largely of beds of unconsolidated sand and clay dipping gently toward the coast. Another large area of outcrop of Tertiary rocks is in the High Plains, where the Ogallala formation of Pliocene age forms the surface of the plains and lies as a mantle on Cretaceous and Triassic rocks.

The Quaternary formations of Texas are widespread in outcrop. A narrow belt of Quaternary sand and clay extends along the entire coast. Alluvium occurs in many places in Texas, especially along the stream valleys. Most of the alluvial deposits are thin, although in a few places great thicknesses are found and the deposits form extensive aquifers.

The aquifers that furnish large quantities of fresh water to wells in Texas are few in comparison to the total number of geologic formations. Although the aquifers have been described rather thoroughly in the literature, the hydrologic descriptions, of course, have been largely confined to the parts that contain fresh water. Some of these same aquifers probably are capable of yielding large quantities of saline water in areas where fresh water is not present. Other aquifers that yield only saline water are known and have been discussed in the literature to a lesser extent. This discussion will be limited to those aquifers generally capable of yielding 100 gallons per minute (gpm) or more to individual wells; yields of 100 to 200 gpm are considered small, 200 to 500 gpm, moderate, and above 500 gpm, large. The aquifers will be described in order from oldest to youngest. The following list of saline-water aquifers includes only those that are known to yield saline water. Some of them yield fresh water near the outcrop and saline water at greater depth.

Saline-water aquifers in Texas.

Age	Formation or group	Character of rocks	Saline-water supply
Recent and Pleistocene.	Alluvium and beach deposits.	Sand, silt, clay, and gravel.	Large supplies available in Pecos Valley and trans-Pecos region and lower Rio Grande valley. Small supplies from beach deposits along coast.
Pleistocene.	Beaumont clay.	Clay and sand.	Small to large supplies available along coast.
Pleistocene, Pliocene(?), and Pliocene.	Lissie formation, Willis sand, and Goliad sand, undifferentiated.	Sand, gravel, silt, and clay.	Capable of producing large supplies along coast.
Pliocene.	Ogallala formation.	Sand, gravel, silt, and clay.	Capable of producing moderate supplies in some areas in High Plains.
Miocene(?) and Miocene.	Lagarto clay, Oakville sandstone, and Catahoula sandstone, undifferentiated.	Principally sand and clay. Tuff and sandstone common in lower part.	Probably capable of yielding small to moderate supplies in parts of West Gulf Coastal Plain.
Eocene.	Jackson group and upper part of Claiborne group, undifferentiated.	Medium- to fine-grained sand, and clay.	Probably capable of yielding small supplies in parts of West Gulf Coastal Plain.
	Sparta sand.	Medium- to fine-grained sand and shale.	Probably a potential source of large supplies, especially in east Texas.
	Mount Selman formation.	Sand and clay; some glauconite and lignite. Sand predominant in middle member.	Probably a potential source of small supplies in parts of the West Gulf Coastal Plain.
	Carrizo sand.	Medium-grained sand and sandy clay.	Potential source of large supplies throughout a large area on the West Gulf Coastal Plain
	Wilcox group.	Sand, clay, silt, and lignite.	Potential source of moderate to large supply throughout a large area on the West Gulf Coastal Plain.

Cretaceous.	Navarro group undifferentiated and Nacatoch sand.	Sand and sandy clay.	Potential source of moderate supplies in parts of northeast Texas.
	Blossom sand.	Sand and clay.	Probably a potential source of moderate supplies in parts of northeast Texas.
	Woodbine sand.	Sand and sandy clay.	Potential source of large supplies through a large area in northeast Texas.
	Edwards limestone and associated limestones.	Limestone and shale. Limestone commonly fissured and channeled.	Potential large source in south-central Texas. Limestone possibly equivalent to the Edwards supplies saline water to springs in Balmorhea area.
	Trinity group.	Sand and limestone.	Capable of yielding moderate to large supplies throughout large areas in central and west Texas.
Triassic.	Dockum group.	Red shale and clay; some sandstone and conglomerate.	Capable of yielding small to moderate supplies in parts of west Texas.
Permian.	Rustler limestone in Pecos Valley region. Quatermaster formation in Osage Plains Region.	Limestone and dolomite in Pecos Valley region. Red shale and sandstone with dolomite and gypsum in Osage Plains region.	Yields large supplies in Pecos Valley region. Potential source of small to moderate supplies in Osage Plains region.
	Blaine gypsum.	Red and gray shale, gypsum, dolomite, and some sandstone.	Potential source of moderate to large supplies in parts of Osage Plains region.
	San Angelo sandstone.	Sandstone and conglomerate; some shale.	Potential source of small supplies in parts of Osage Plains region.
	Clear Fork and Wichita groups in Osage Plains region. Delaware Mountain group and Bone Spring limestone in Pecos Valley and trans-Pecos Regions.	Red shale and sandstone and beds of limestone and dolomite in Osage Plains region. Sandstone and limestone in Pecos Valley and trans-Pecos regions.	Potential source of small supplies in parts of Osage Plains region. Yields large supplies locally in trans-Pecos region.
Pennsylvanian.	Undifferentiated.	Limestone, shale, and some sandstone.	Potential source of small supplies locally in Osage Plains region.
Ordovician.	Ellenburger group.	Limestone and dolomite.	Probably a potential source of moderate to large supplies in parts of central and west Texas.
Cambrian.	Hickory sandstone member of the Riley formation.	Sandstone and conglomerate.	Probably a potential source of moderate to large supplies in parts of central Texas.

The maps and tables of analyses show the salinity of ground and surface water at many specific places. No attempt was made, however, to delineate zones or areas of differing salinity in each aquifer, as a guide to the location of supplies of relatively low salinity. For most aquifers considerable additional study of existing data, and many new data, would be necessary for such a delineation.

CAMBRIAN SYSTEM

HICKORY SANDSTONE MEMBER OF THE RILEY FORMATION

The oldest aquifer believed capable of yielding large quantities of water to wells in Texas is the Hickory sandstone member of the Riley formation, of Cambrian age. The Hickory crops out on the flanks of the Llano uplift in central Texas (fig. 2). It dips away from the uplift in all directions and is found at increasing depths away from the Llano area. Yields of 750 gpm have been obtained for public supply at Eden in Concho County and Brady in McCulloch County. Although the Hickory sandstone member furnishes fresh water in most places where it is now used (though not at Eden), it probably contains saline water at greater depth and may be a potential source of large quantities of such water in a small area in central Texas.

The quality of saline water from the Hickory sandstone member is represented by a single analysis of the public supply at the city of Eden. (See well CO–1 in table 1.) The depth of the well at Eden is 4,410 feet. The observed dissolved-solids content was 1,110 ppm, and, therefore, the water could be classified as slightly saline. At Eden the water of the Hickory is predominantly of the sodium chloride type and has a percent sodium of 95. Three wells, ranging in depth from 2,082 to 2,114 feet, are yielding fresh water from the Hickory sandstone for municipal use at Brady in McCulloch County (Sundstrom, Broadhurst, and Dwyer, 1949, p. 81).

ORDOVICIAN SYSTEM

ELLENBURGER GROUP

The Ellenburger group of Ordovician age consists largely of a series of limestones and dolomites. This group crops out on the flanks of the Llano uplift in central Texas and dips steeply away in all directions (fig. 2). According to Sellards (*in* Sellards, Adkins, and Plummer, 1932, p. 72), the Ellenburger ranges from a thin stratum to 2,000 feet in thickness. From oil-well drilling the Ellenburger is known to exist throughout a large area in west and

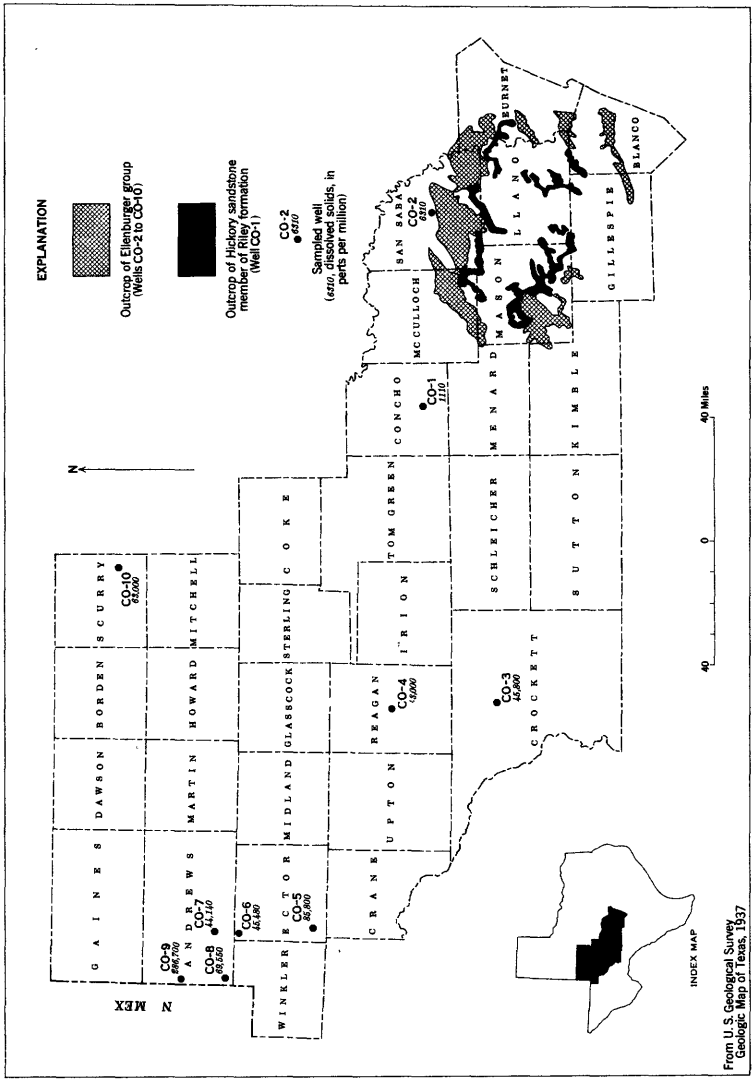


Figure 2.—Map showing locations of wells sampled and areas of outcrop of Hickory sandstone member of Riley formation and Ellenburger group.

north-central Texas, extending into Oklahoma. It yields moderately large quantities of fresh water to public-supply wells at Burnet and at Fredericksburg; two of the wells at Fredericksburg have been tested at 550 gpm each.

It seems probable that the Ellenburger could produce large quantities of saline water throughout a large area in west Texas, although the depths of the wells would be greater than 5,000 feet in most places. Much information on the water of the Ellenburger is available in the files of oil companies, because the Ellenburger is one of the principal oil-producing units in west Texas.

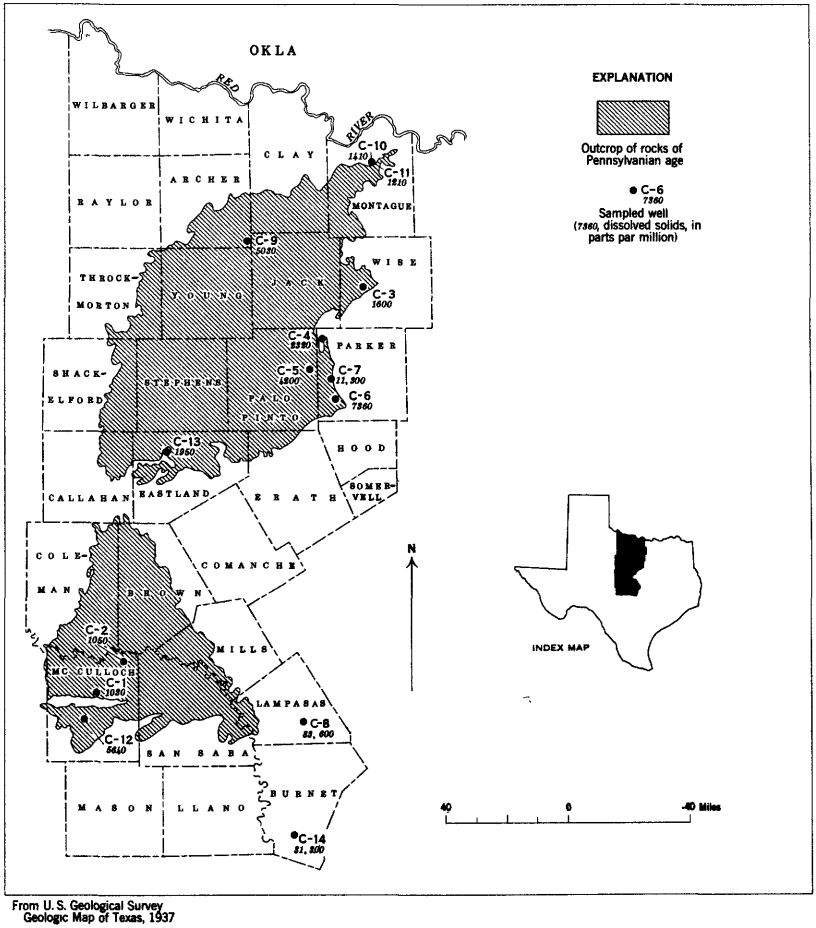
The quality of the saline water from the Ellenburger group is represented by analyses of waters from wells CO–2 to CO–10, shown in table 1. Analyses of water from wells CO–3 and CO–5 to CO–10 were furnished by the Humble Oil and Refining Co. The observed concentration of dissolved solids ranges from 6,310 ppm at a depth of 560 feet in San Saba County to 286,700 ppm at a depth of 10,531 feet in an oil test in Andrews County. The locations of the wells that were sampled are shown in figure 2.

PENNSYLVANIAN SYSTEM

The rocks of the Pennsylvanian system are relatively unimportant as aquifers in Texas, although in parts of north-central Texas small supplies of water are obtained from them. They consist principally of a series of limestones and shales and a few sandstones. The Pennsylvanian rocks crop out in the Llano area and dip gently away from the Llano uplift in all directions. They crop out also in a belt along the east edge of the Osage Plains where they dip gently toward the west and northwest (fig. 3).

Small quantities of saline water are obtained from Pennsylvanian rocks at Mineral Wells in Palo Pinto County. Some of this water is used for public supply, and some of it is used as mineral water in health resorts at Mineral Wells.

The observed concentration of dissolved solids in the saline waters from rocks of Pennsylvanian age ranges from 1,030 ppm in McCulloch County to 83,600 ppm in Lampasas County, as shown in table 1. The locations of the wells from which the samples were taken are shown in figure 3.



From U. S. Geological Survey
Geologic Map of Texas, 1937

Figure 3.—Map showing locations of wells sampled and principal areas of outcrop of rocks of Pennsylvanian age in Osage Plains region.

PERMIAN SYSTEM

The Permian formations in Texas include some of the most important saline-water aquifers in the State. The Permian rocks crop out in the Osage Plains region of north-central Texas and in places in trans-Pecos Texas. These two areas of outcrop are connected in the subsurface through the Permian basin. The Permian outcrop area is one in which there is a scarcity of potable water but a relative abundance of highly mineralized water. An economical demineralization process would be very helpful to the inhabitants of this region.

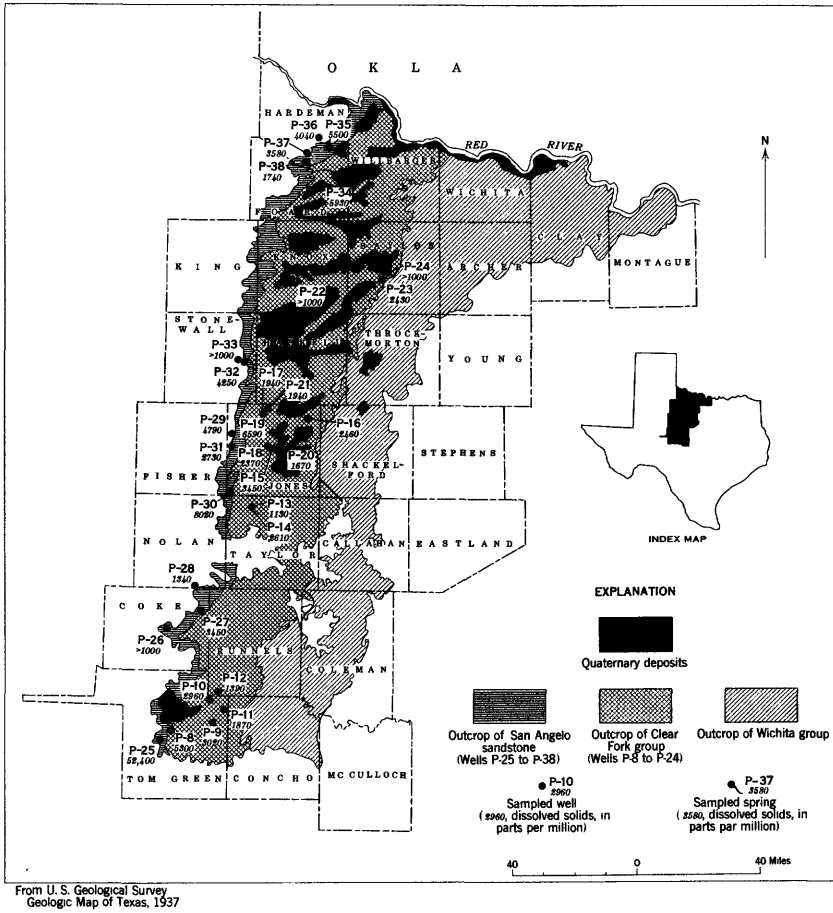
In the Osage Plains region the principal saline-water aquifers include limestones and dolomites of the Wichita and Clear Fork groups, the San Angelo sandstone, the Blaine gypsum, and the Quartermaster formation. These formations crop out in a belt extending from Tom Green and Concho Counties on the south into Oklahoma on the north (figs. 4 to 7). The belt is bounded on the west by the outcrop of the Triassic formations and the High Plains escarpment and on the east by the outcrop of the Pennsylvanian rocks. In the Osage Plains the Permian rocks dip gently toward the west and northwest. The rocks consist of a series of shale, limestone, dolomite, gypsum, and sandstone strata having a total thickness of 4,000 to 5,000 feet.

In places in the Pecos Valley and trans-Pecos regions, Permian limestones and dolomite supply large quantities of saline water, much of which is used for irrigation. The principal saline-water aquifers in this region are the Bone Spring and Rustler limestones.

WICHITA AND CLEAR FORK GROUPS

In the Osage Plains region (fig. 4) the largest supplies of water probably occur in the limestones and dolomites of the Wichita and Clear Fork groups. One of the most important of these is the Bullwagon dolomite member of the Vale formation. Although this member is thin, it yields small to moderate quantities of water. Some irrigation wells producing water from the Bullwagon in Tom Green County are reported to have initial yields of 1,000 gpm (Willis, 1954). A well tapping the Bullwagon at Anson in Jones County is reported to have yielded 500 gpm when drilled. Because the water occurs in fissures and solutional channels in the limestones and dolomites, production is spotty; however, yields similar to those obtained in Tom Green County might be obtained in places in the central part of the Osage Plains region.

The chemical quality of saline water from the Wichita and Clearfork groups is shown in table 1. The Bullwagon member of the Vale formation yields water to public-supply wells at Merkel in Taylor County, at Miles in Runnels County, and at Anson in Jones County. The water from the Wichita and Clear Fork ranges from slightly saline to moderately saline and is the calcium magnesium sulfate type. The water from well P–16 in Jones County contains 5.5 ppm of boron. Locations of the wells sampled are shown in figure 4.



From U. S. Geological Survey Geologic Map of Texas, 1937

Figure 4.—Map showing locations of wells and springs sampled and areas of outcrop of Wichita and Clear Fork groups and San Angelo sandstone.

SAN ANGELO SANDSTONE

The San Angelo sandstone crops out in a narrow belt extending from Tom Green County on the south into Oklahoma at the Hardeman-Wilbarger County line (fig. 4). It dips gently toward the west. This formation consists principally of sandstone and conglomerate and some shale. In places, especially in or near the outcrop area, the sandstone has sufficient permeability to supply small quantities of water to wells.

The water from the San Angelo contains principally calcium and magnesium sulfates and is therefore hard. Chemical analyses of

the water from wells 34 to 1,150 feet deep show a range in dissolved solids from 1,340 to 52,400 ppm. One incomplete analysis of the water from a well 1,140 feet deep shows a chloride content of 30,000 ppm. Water issuing from springs near the base of the San Angelo sandstone in Hardeman County contains dissolved solids as high as 3,580 ppm. Analyses of waters from the San Angelo sandstone are shown in table 1. The location of the wells and springs from which the samples were taken are shown in figure 4.

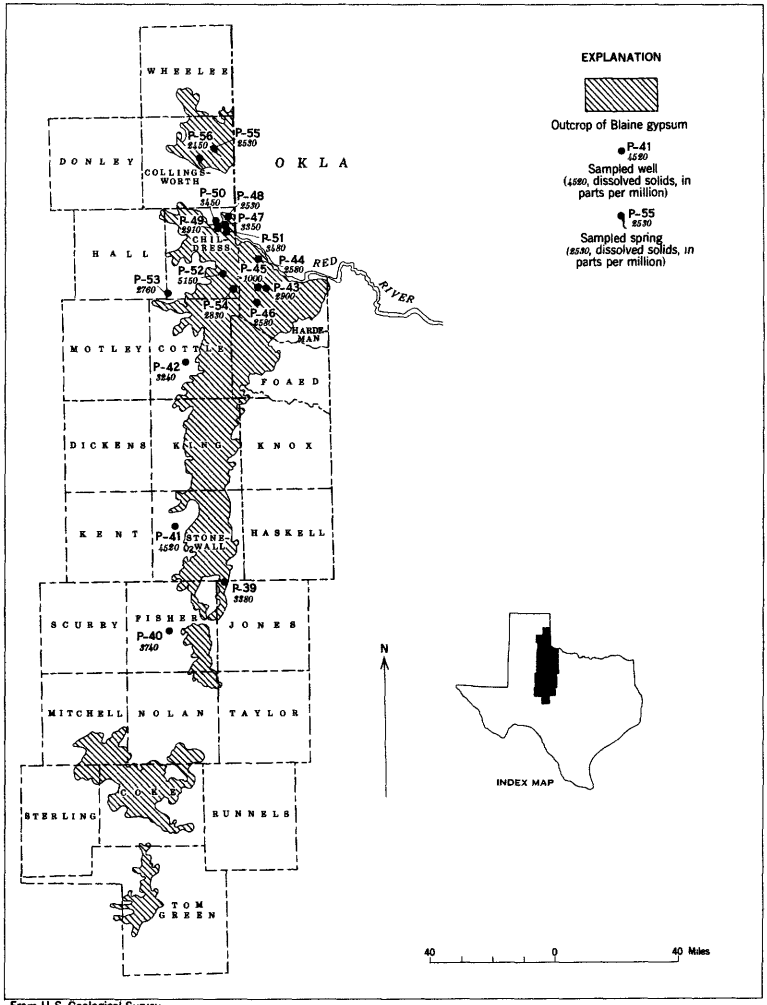
BLAINE GYPSUM

The Blaine gypsum crops out in a south-trending belt in the western part of the Osage Plains region (fig. 5). According to Sellards (*in* Sellards, Adkins, and Plummer, 1932, p. 178) the Blaine consists of red and gray shale, massive beds of gypsum, dolomite, and some sandstone. The Blaine dips gently to the west where it is overlain by the Quartermaster formation. Yields of 1,400 gpm have been reported from irrigation wells ranging in depth from 100 to 300 feet in Childress and Hardeman Counties. Much of the water is probably obtained from solutional cavities in the easily dissolved gypsum. The Blaine is believed to be a potential source of moderate to large quantities of saline water in parts of Nolan, Fisher, Stonewall, King, Cottle, Foard, Hardeman, Childress, and Collingsworth Counties.

Water from wells and springs tapping the Blaine gypsum is of the calcium and magnesium sulfate type. A few of the irrigation wells in Childress County yield water that contains as much as 4 ppm of boron. Water from springs discharging from the Blaine in Collingsworth County is slightly saline. The observed dissolved-solids content of water from wells and springs ranges from 2,450 ppm in a spring in Collingsworth County to 5,150 ppm from a well 270 feet deep in Childress County. Water analyses are shown in table 1, and the locations of the wells and springs sampled are shown in figure 5.

QUARTERMASTER FORMATION

For the purpose of this report, the term Quartermaster formation is used to include all the Permian strata above the Blaine gypsum in the Osage Plains region. The Quartermaster consists of red shale and fine-grained sandstone and thin layers of dolomite and gypsum. The formation crops out in a south-trending belt in the western part of the Osage Plains region and dips gently to the west (fig. 6). The Quartermaster yields small supplies of water to wells in the region, although moderately large supplies



From U.S. Geological Survey Geologic Map of Texas, 1937

Figure 5.—Map showing locations of wells and springs sampled and area of outcrop of the Blaine gypsum.

might be obtained in some areas where solution channels occur in the dolomite or gypsum beds or where more permeable zones occur in the sandstones.

Chemical analyses of water from wells and springs producing from the Quartermaster formation are shown in table 1. Water from wells, 70 to 585 feet deep, ranges in dissolved solids from 1,680 to 6,440 ppm. Water from springs issuing from the forma-

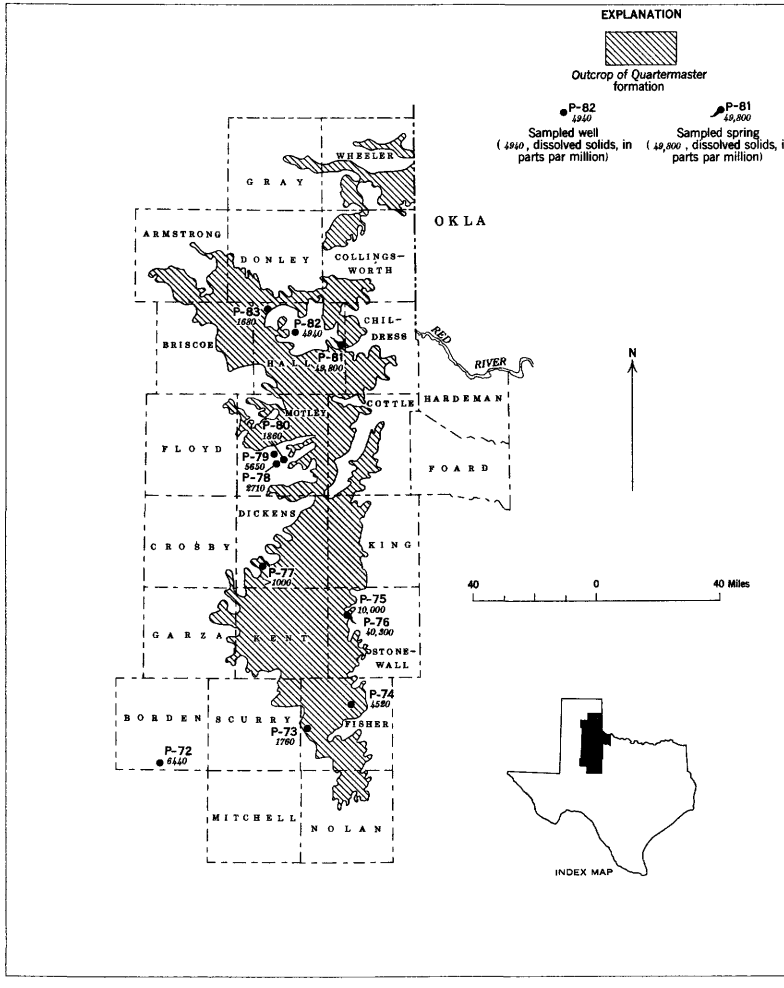


Figure 6.—Map showing locations of wells and springs sampled and areas of outcrop of the Quartermaster formation.

tion in Stonewall and Hall Counties is classified as very saline or as brine, as the observed dissolved-solids concentration ranges from 10,000 to 49,800 ppm. A spring (P–81) in Hall County was reported to be flowing about 500 to 600 gpm of saline water in May 1943. Locations of wells and springs sampled are shown in figure 6.

BONE SPRING LIMESTONE

The oldest of the Permian formations that produces water in the trans-Pecos region is the Bone Spring limestone. This formation crops out on the west side of the Salt Basin and is disclosed in wells at shallow depth in the Dell City area in Hudspeth County (fig. 7). It consists almost entirely of limestone. In some places the limestone is cherty and in other places dolomitic. According to Scalapino (1950, p. 5–6) the Bone Spring limestone in the Dell City area produces water from joints and solution channels. In 1949, 32 irrigation wells with yields ranging from 350 to 3,000 gpm were in use in the area (Scalapino, 1950, p. 7).

Analyses of water from the Bone Spring limestone are shown in table 1. The water from the Bone Spring in the Dell City area falls in the slightly saline class. The observed concentration of dissolved solids ranges from 1,120 ppm in a well 250 feet deep to 1,800 ppm in a well 60 feet deep. The water in this area is used principally for irrigation (Scalapino, 1950, p. 7). The locations of wells that were sampled are shown in figure 7.

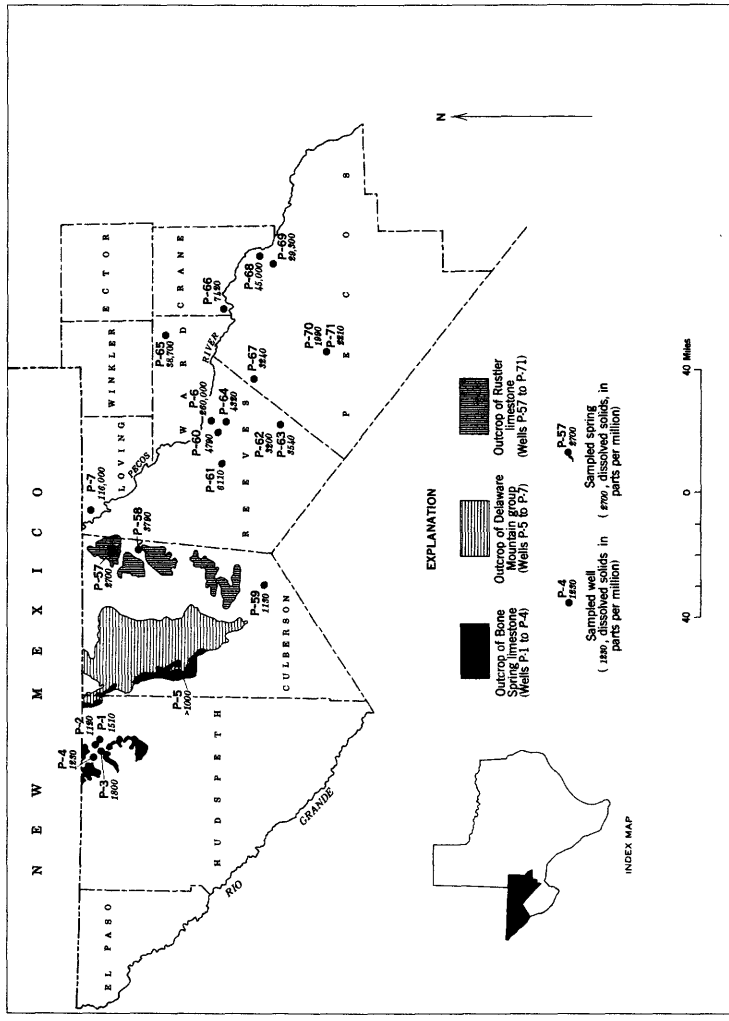
DELAWARE MOUNTAIN GROUP

The Delaware Mountain group consists principally of sandstone and limestone. The group crops out in the Delaware Mountains in Culberson County where it has a thickness of about 2,700 feet (fig. 7). The unit is buried beneath younger deposits in the Pecos Valley area. Knowles and Lang (1947, p. 6) report that the Delaware Mountain group occurs at depths ranging from 2,500 to 5,200 feet in Reeves County, where it has been disclosed by many oil tests. Saline water is present in varying amounts where no oil is found and in some places is under sufficient pressure to flow.

Analyses of water from the Delaware Mountain group are shown in table 1. Not enough data are available on the quality of the water from the Delaware Mountain group to establish the general range in concentration or composition. Water from one well 5,100 feet deep, in Reeves County, contains 159,000 ppm of chloride. A well 2,400 feet deep, in Culberson County, yields water containing 922 ppm of chloride. Locations of wells tapping the Delaware Mountain group are shown in figure 7.

RUSTLER LIMESTONE

The Rustler limestone crops out in an area extending from the Texas-New Mexico line, where the outcrop appears in the bed of



From U.S. Geological Survey Geologic Map of Texas, 1937

Figure 7.—Map showing locations of wells and springs sampled and areas of outcrop of the Bone Spring limestone, Delaware Mountain group, and Rustler limestone.

the Pecos River, southward nearly to the Davis Mountains (fig. 7). It forms the Rustler Hills in eastern Culberson County. The Rustler dips to the east and is overlain by differing thicknesses of younger formations in Loving, Ward, and Crane Counties and adjacent counties on the east. The Rustler consists largely of dolomitic limestone and smaller amounts of sandstone and conglomerate in the outcrop area, where the total thickness is about 200 feet. It thickens eastward from the outcrop area. Knowles and Lang (1947, p. 7) report that the maximum thickness in Reeves County is about 500 feet.

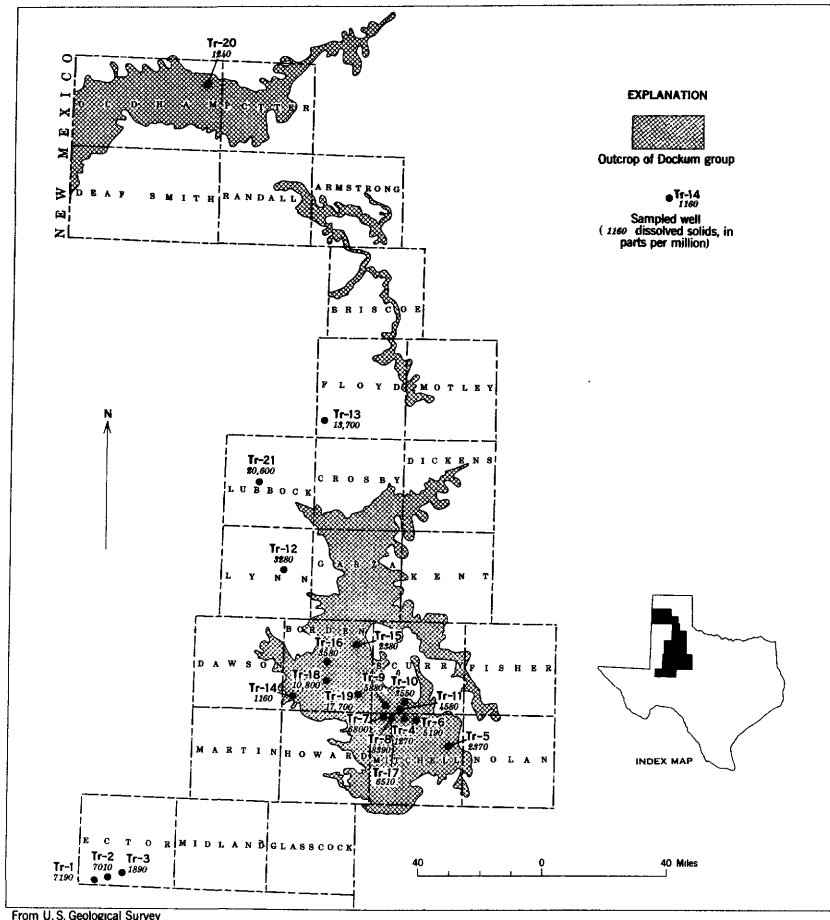
The Rustler supplies large quantities of water to many irrigation wells in Pecos and Reeves Counties, principally from a porous dolomite near the middle of the formation. Flows of 2,500 gpm have been obtained from some wells in Pecos County, although in some others no water at all was found. Large flows also have been reported from the Rustler in southern Reeves County, but in the northern part of that county no flows have been reported. Although the production from the Rustler limestone is spotty, large quantities of water probably could be obtained from it in parts of Loving, Ward, and Crane Counties, and adjacent counties to the east, as well as from the proved areas in Pecos and Reeves Counties.

Water samples collected from wells tapping the Rustler limestone in the Pecos Valley and trans-Pecos areas contain dissolved solids ranging from 1,180 to 45,000 ppm. The locations of the wells and springs that were sampled are shown in figure 7. From the observed data, sulfate is the principal anion in water containing as much as 5,000 ppm of dissolved solids, but chloride becomes the dominant anion in water containing more than 5,000 ppm of dissolved solids. The percent sodium ranges from 1 in water from a well 5,326 feet deep in Pecos County to 85 in water from an irrigation well in Ward County. Analyses of water from the Rustler limestone are shown in table 1.

TRIASSIC SYSTEM

DOCKUM GROUP

Formations of the Dockum group of Triassic age crop out along the eastern edge of the southern High Plains. They crop out also in small areas in Loving, Ward, Winkler, Scurry, and Crane Counties, and in the valley of the Canadian River (fig. 8). The group underlies most of the High Plains and is present also in the subsurface in a large area east of the Pecos River. The Dockum consists principally of red shale and clay and a few beds of sand-



From U.S. Geological Survey
Geologic Map of Texas, 1937

Figure 8.—Map showing locations of wells sampled and principal areas of outcrop of the Dockum group.

stone and conglomerate. The sands of the Dockum are generally fine grained and tightly cemented, and consequently the permeability is low. Locally, however, moderately large quantities of water may be obtained. For example, in Mitchell County, irrigation wells ranging in depth from 115 to 315 feet and yielding an average of about 250 gpm each are producing from Triassic sand and gravel (Dale and Broadhurst, 1953, p. 1).

Water from the Dockum group differs in composition with local conditions. The observed concentration of dissolved solids in the saline water ranges from 1,160 ppm at a depth of 60 feet to 20,600 ppm at a depth of 999 feet. In general, the water is of the sodium

chloride type at higher concentrations (more than about 5,000 ppm of dissolved solids). At concentrations of less than about 3,000 ppm and at shallow depths, the waters of the Dockum are heterogeneous in chemical composition, although sulfate is generally the predominant anion. Analyses of saline water from the Dockum group are shown in table 1, and the locations from which the samples were taken are shown in figure 8.

CRETACEOUS SYSTEM

TRINITY GROUP

The Trinity group of Early Cretaceous age has been divided into three formations; from oldest to youngest they are the Travis Peak formation, the Glen Rose limestone, and the Paluxy sand. The group crops out principally in a belt extending from the Oklahoma State line at Montague and Cooke Counties southward to Travis County, thence southwestward into Bandera County where it passes beneath the Fredericksburg group (pl. 1). The Trinity is also exposed locally farther westward. The group dips toward the east and southeast where it is overlain by younger formations.

The basal unit of the Trinity group, the Travis Peak formation, consists largely of sandstone and conglomerate and some shale and limestone in northeast and north-central Texas. Yields of 500 gpm are common from wells tapping the Travis Peak formation in the vicinity of Fort Worth and Dallas. The Travis Peak contains less sand and yields smaller quantities of water to wells in central and south-central Texas along the Balcones fault zone.

The Glen Rose limestone consists typically of alternating limestone and marl. It yields small to moderate quantities of water to wells and springs, especially in areas where the limestone is porous or cavernous.

The upper formation of the Trinity group, the Paluxy sand, consists largely of fine-grained quartz sand and some shale. It yields moderate quantities of water to wells in north-central Texas.

The chemical quality of the water from the Trinity group is shown in table 1. Water from the Trinity in north- and south-central Texas is mainly of the sodium sulfate and sodium chloride types. The observed dissolved-solids content in areas where the water is saline ranges from 1,010 ppm at a depth of more than 2,000 feet in Milford, to 8,020 ppm at a depth of about 3,300 feet at Marlin. Water from the Trinity group is high in fluoride

content, which exceeds 1.5 ppm in all but a few samples. Water from a well 1,320 feet deep in Williamson County contained 7.2 ppm of fluoride.

Sulfate is the main constituent in waters from the Trinity group in the Edwards Plateau region. Most of the water from the Trinity in that region falls in the slightly saline class, and the observed samples contained from 459 to 1,460 ppm of sulfate. Several cities in this area are supplied with water obtained from wells tapping the Trinity group (pl. 1).

Many cities in north- and south-central Texas obtain water from the formations of the Trinity group. Although it is one of the most important fresh-water aquifers in Texas, moderate to large quantities of saline water could be produced from the Trinity. Flowing wells, yielding 500 gpm, have been reported by well owners in Hill, McLennan, and Falls Counties. A well owned by the city of Dallas was being pumped at a rate of 1,000 gpm in 1950. Some water from the Trinity used for public supply falls in the slightly saline and moderately saline classifications. The observed dissolved-solids content of the saline water from public-supply wells ranges from 1,010 to 5,580 ppm. Hardness as $CaCO_3$ ranges from 20 to 906 ppm.

EDWARDS LIMESTONE AND ASSOCIATED LIMESTONES

The Edwards limestone and associated limestones of Early Cretaceous age crop out east and north of the Balcones fault zone in central and south-central Texas and in a large area on the Edwards Plateau (pl. 2). They crop out also in smaller areas in west Texas. The Edwards limestone has one of the highest yields of the aquifers in Texas. It consists mostly of massive light-colored limestone that is honeycombed and cavernous in places. The water in the Edwards occurs in cracks and fissures and in solution channels. The formation furnishes large quantities of water of good quality to wells in the San Antonio area and in parts of Kinney, Uvalde, Medina, Bexar, Comal, and Hays Counties. A well tapping the Edwards at San Antonio is reported to have had a flow of 16,600 gpm on June 16, 1942 (Livingston, 1942, p. 3), and is believed to be the largest natural flow on record in the United States. The Edwards also supplies water to the large springs along the Balcones fault zone, such as Barton Springs at Austin, San Marcos Springs at San Marcos, and Comal Springs at New Braunfels. South and east of the fault zone the Edwards contains saline water. In the San Antonio area it is reported (Livingston, Sayre, and White, 1936, p. 104) that the line of demarcation between the nonsaline water to the north and saline water to

the south is so sharp as to suggest that a fault cuts off free circulation of water from the north to the south, thereby preventing the flushing of saline water from the aquifer. A similar condition probably exists along the fault zone both to the northeast and to the west from San Antonio, where saline water occurs south and east of the fault. Large quantities of saline water probably could be produced from the Edwards in places south and east of the fault zone. For example, flows of 700 gpm of saline water have been obtained from the Edwards near Thorndale in Milam County.

Limestones which are probably equivalents of the Edwards and associated limestones occur under a large area in the Pecos Valley region where they supply large quantities of water to springs in Pecos and Reeves Counties.

The observed dissolved-solids content in the saline water from the Edwards limestone along the Balcones fault zone differs greatly, ranging from 1,010 ppm in Kinney County to 14,800 ppm in Milam County. The water is of the calcium sulfate type in the lower concentrations and of the sodium chloride-sulfate type in the higher concentrations.

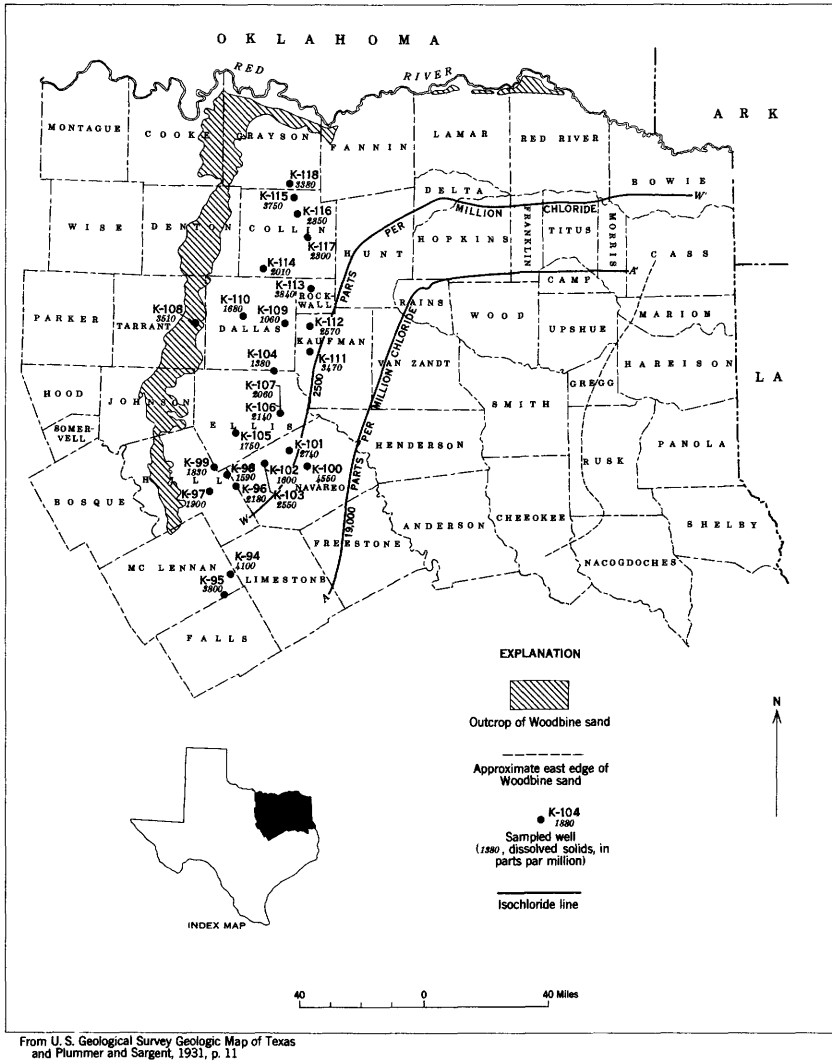
The artesian springs near Balmorhea, Reeves County, are believed to have their source in limestone of Early Cretaceous age (White, Gale, and Nye, 1941, p. 90). The dissolved-solids content of these artesian spring waters varies considerably with discharge. During periods of normal flow the waters from Phantom Lake, San Solomon, and Giffin Springs each contain slightly more than 2,000 ppm of dissolved solids; however, San Solomon Spring, during a period of high flow on October 7, 1932, yielded water containing only 562 ppm of dissolved solids (White, Gale, and Nye, 1941).

Analyses of the water and locations of the wells and springs sampled are shown in table 1 and plate 2, respectively.

WOODBINE SAND

The water of the Woodbine sand has been described by Plummer and Sargent (1931), and the following discussion is based largely on their work.

The Woodbine sand of Late Cretaceous age is one of the chief aquifers in northeast Texas. Figure 9 shows that it crops out in a belt extending from northern McLennan County northward through Hill, Johnson, Tarrant, and Denton Counties to Cooke County, thence it swings eastward, lying roughly parallel to the Red River,



From U. S. Geological Survey Geologic Map of Texas and Plummer and Sargent, 1931, p. 11

Figure 9.—Map showing locations of wells sampled and area of outcrop and approximate subsurface extent of the Woodbine sand and lines denoting chloride concentration.

nearly to the Arkansas State line. The Woodbine dips toward the east and south from the outcrop area and supplies as much as 500 gpm of fresh water to wells in a belt about 40 miles wide lying parallel to the outcrop area. According to Plummer and Sargent (1931, p. 10) the formation is a broad wedge of sand and sandy

clay which is thickest at the outcrop and which thins southeastward, extending beneath the surface 120 miles east and west and 150 miles north and south over an area of at least 18,000 square miles. The amounts of chloride and of dissolved solids in the water increase gradually from the northwest to the southeast. One line in figure 9, about 40 miles from the outcrop, shows the chloride content of the water to be about 2,500 ppm; the other line shows the chloride content to be about 19,000 ppm.

The observed concentration of dissolved solids in saline water of the Woodbine ranges from 1,060 ppm in Dallas County to 4,550 ppm in Navarro County. According to Plummer and Sargent (1931, p. 48):

> The concentration in general increases with depth, but is governed to a considerable extent by the freedom of circulation, which in turn is controlled by local and regional structure. As the distribution of chloride is also affected by this same condition, marked variation in the total concentration of the deeper waters is usually associated with variation in the proportion of chloride.

Sodium is the principal cation in water of the Woodbine, and content of percent sodium as high as 99 was observed.

The fluoride content of the water of the Woodbine generally exceeds 1.5 ppm; fluoride concentrations as great as 6.0 ppm are present in the supplies of several cities drawing water from the Woodbine.

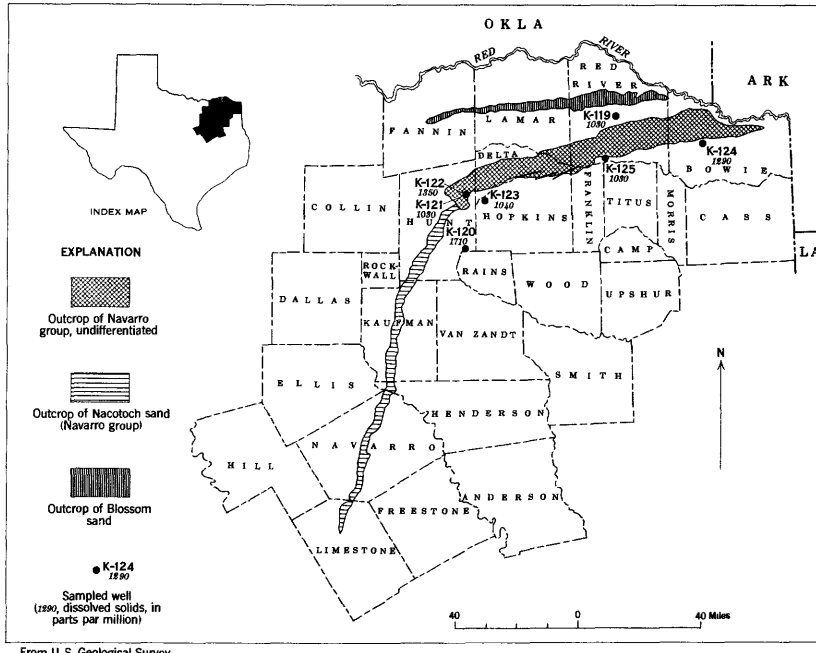
Analyses of the water and locations of the wells are shown in table 1 and figure 9, respectively.

BLOSSOM SAND

The Blossom sand of Late Cretaceous age crops out in a narrow west-trending belt in Red River, Lamar, and Fannin Counties in northeast Texas (fig. 10). According to Adkins (*in* Sellards, Adkins, and Plummer, 1932, p. 444) the Blossom consists of brown sandy ferruginous, glauconitic beds interlaminated with thin clay layers. The formation dips toward the south and supplies soft, slightly saline water to the city of Clarksville in Red River County from wells about 600 feet deep. The analysis of the water from a well, reported to be yielding 650 gpm (K–119, fig. 10), at Clarksville is shown in table 1. Perhaps similar quantities of saline water could be obtained from the formation farther south.

NAVARRO GROUP UNDIFFERENTIATED AND NACATOCH SAND

The Nacatoch sand of the Navarro group of Late Cretaceous age crops out in a narrow belt extending westward across Bowie, Red River, and Delta Counties to Hunt County where the outcrop is shown on the map (fig. 10) included with the Navarro group, undifferentiated. In Hunt County the outcrop trends southward through Kaufman and Navarro Counties to northern Limestone County (fig. 10). From Hunt County southward the outcrop of the Nacatoch is differentiated. The formation consists largely of sand and sandy clay and locally contains glauconite. In places the sand is finely cemented and may be concretionary (Sellards, Adkins, and Plummer, 1932, p. 493).



From U. S. Geological Survey Geologic Map of Texas, 1937

Figure 10.—Map showing locations of wells sampled and areas of outcrop of Blossom sand, Nacatoch sand, and Navarro group undifferentiated.

The Nacatoch sand furnishes moderate quantities of fresh water to public-supply wells at Bogata in Red River County, Commerce and Quinlan in Hunt County, and Cumby in Hopkins County. Yields of 335 gpm have been reported. The city of Talco in Titus County draws slightly saline water from a well tapping the

Nacatoch in Red River County. The Nacatoch is known to occur in the subsurface throughout a large area in northeast Texas and is probably capable of yielding moderate quantities of saline water to wells in the area.

Sulfate constitutes about two-thirds of the total number of anions at depths of about 180 feet in Hunt County. At greater depths the content of chloride increases, to about 50 percent of the total number of anions. Analyses of the water and locations of the wells are shown in table 1 and figure 10, respectively.

TERTIARY SYSTEM

EOCENE SERIES

WILCOX GROUP

The sands of the Wilcox group of Eocene age are the oldest important Tertiary aquifers in Texas. The Wilcox crops out in northeast and east Texas on the limbs of the east Texas syncline. On the northwest limb the outcrop extends in a belt from the Arkansas State line westward across Bowie, Morris, Titus, and Franklin Counties into Hopkins County, thence southwestward to Freestone County (pl. 3). The Wilcox is overlain by younger Eocene formations in the syncline, but it crops out again on the southeast limb throughout all of Shelby and Panola Counties and parts of Marion, Harrison, Gregg, Rusk, and Nacogdoches Counties. Southwest from the area of the syncline, the Wilcox crops out in a belt extending southwestward from Freestone County to Guadalupe County, thence the outcrop trends more toward the west, extending to Uvalde County where it trends to the south, extending into Mexico near the northwestern corner of Webb County. In south Texas the Wilcox group is represented by the Indio formation only.

In areas away from the influence of the east Texas syncline, the Wilcox dips toward the coast, passing beneath the younger formations of the West Gulf Coastal Plain. According to Plummer (*in* Sellards, Adkins, and Plummer, 1932, p. 573) the Wilcox group consists of a thick series of sandy, lignitiferous littoral clays, crossbedded river sands, noncalcareous lacustrine or lagoonal clays, lignite lentils, and stratified deltaic silts. The upper part of the group has a greater proportion of sand than the lower part.

The Wilcox is the principal aquifer in the area of the east Texas syncline, furnishing large quantities of fresh water to wells in the area. Some of the wells yield more than 1,000 gpm. Through-

out the remainder of east Texas and in south Texas, the Wilcox supplies smaller quantities of water, and the water is generally more highly mineralized, the effects of mineralization increasing downdip.

The Wilcox group furnishes fresh water to many cities in east Texas. At Kilgore in Gregg County the Wilcox yields slightly saline water to wells at depths of 800 to 900 feet.

The chemical quality of waters from the Wilcox differs locally because of the complexity of the lithology of the group. Analyses of water from the Wilcox are shown in table 1. According to Broadhurst (1950, p. 70) the dissolved solids in water of the Wilcox in Gregg County consist mainly of sodium, bicarbonate, and chloride. Generally the lower sands yield more highly mineralized water than the upper sands. In the Winter Garden district in Zavala and Dimmit Counties and eastern Maverick County, the Indio formation of the Wilcox group yields water of a mixed type, both sodium sulfate and sodium chloride being noted. Concentrations of 1,750 ppm of sulfate have been found in the water of the Wilcox from this area.

The observed dissolved-solids concentration in saline water from the Wilcox group ranges from about 1,000 to nearly 7,000 ppm. The locations of the wells for which analyses of saline water are available are shown in plate 3.

CARRIZO SAND

The Carrizo sand of the Claiborne group of middle Eocene age has one of the highest yields of the aquifers in Texas. The regional distribution of the outcrop of the Carrizo is similar to that of the Wilcox group. The Carrizo crops out on the limbs of the east Texas syncline lying parallel to and adjoining the Wilcox outcrop (pl. 3). It is mantled by younger Eocene formations in the syncline. In the area southwest of the syncline, the Carrizo crops out in a narrow belt along the southeast edge of the Wilcox outcrop.

In the area away from the influence of the east Texas syncline the Carrizo dips toward the coast beneath younger formations. In most places the Carrizo is easily identified in well logs and it has been traced long distances down the dip from the outcrop. The Carrizo sand consists of about nine-tenths medium-grained sand and one-tenth sandy clay (Sellards, Adkins, and Plummer, 1932, p. 617). The sand generally is slightly coarser than that of

the Wilcox group. The individual sand strata are generally thick and massively bedded. Crossbedding is conspicuous.

The Carrizo supplies large quantities of fresh water to irrigation wells in the Winter Garden district in south Texas, some of the wells yielding more than 1,000 gpm. The Carrizo also furnishes large quantities of water to public-supply and industrial wells in south and east Texas in a belt lying parallel to the outcrop on the southeast. Flowing wells about 4,000 feet deep near Campbellton in south Texas, about 30 miles downdip from the outcrop, yield 1,000 gpm of water containing about 600 ppm of dissolved solids (see E–33 in table 1).

The observed dissolved-solids content of saline water from the Carrizo sand ranges from 1,080 to 7,430 ppm. The Carrizo sand yields slightly saline sodium bicarbonate water to wells in La Salle, McMullen, Atascosa, Lee, and Brazos Counties, at depths ranging from about 1,300 to 4,150 feet. The carbonate and bicarbonate ions constitute more than 60 percent of the total anions. At shallower depths in Webb, Atascosa, Medina, Caldwell, and Bastrop Counties the water is principally of the sodium chloride and sodium sulfate types. In some places in south Texas the nonsaline water of the Carrizo is contaminated through leaky wells by highly mineralized water from the overlying Bigford member of the Mount Selman formation. Analyses of water from wells tapping the Carrizo sand are shown in table 1. The locations at which the samples were taken are shown in plate 3.

MOUNT SELMAN FORMATION

The Mount Selman formation of the Claiborne group of middle Eocene age consists of three members; in order from oldest to youngest they are the Reklaw member or Bigford member, the Queen City sand member, and the Weches greensand member. The Queen City sand member is the principal aquifer. The Mount Selman crops out in a belt extending from the Rio Grande in Webb County northward into Zavala County, thence eastward and northeastward into Anderson and Cherokee Counties where the outcrop forks, the south fork extending eastward to the Sabine River in Sabine County and the north fork occupying most of the trough of the east Texas syncline and extending into Arkansas and Louisiana at Cass County (pl. 4). Except in the vicinity of the east Texas syncline the Mount Selman dips gently toward the coast beneath younger formations.

The Queen City sand member of the Mount Selman consists principally of medium- to fine-grained sand and some clay or

shale. The Queen City furnishes small quantities of water of good quality to wells in the area southeast of the outcrop.

The other members of the formation are unimportant as aquifers. In south Texas, however, the Bigford contains saline water, and in areas where the underlying Carrizo sand is heavily pumped the difference in head between the two formations and the presence of faulty casing in some of the wells have caused local contamination of the Carrizo.

The Mount Selman formation yields slightly saline water to public-supply wells in La Salle and Atascosa Counties in south Texas. Locations of wells tapping the Mount Selman formation are shown in plate 4.

The observed dissolved-solids concentration of saline water from the Mount Selman formation ranges from 1,020 to 11,800 ppm. The Bigford member of the formation yields water that ranges from moderately to very saline. Analyses of water from the Mount Selman formation are shown in table 1.

SPARTA SAND

The Sparta sand of the Claiborne group of middle Eocene age crops out principally in a belt extending from the Sabine River in Sabine County westward into Houston County, thence it trends southwestward and, according to Plummer (*in* Sellards, Adkins, and Plummer, 1932, p. 652), has been traced to northeastern Atascosa County. The outcrop area is shown in plate 5; however, south of Wilson County the Sparta and the overlying Cook Mountain formations are undifferentiated. In addition to the principal outcrop area as described, there are isolated outcrops in the trough of the east Texas syncline. In the area south and southwest from the east Texas syncline the formation dips coastward from the outcrop and has been identified in wells many miles down the dip. The Sparta consists principally of medium- to fine-grained sand and some shale and a few beds of glauconite, limonite, and lignite.

The Sparta furnishes moderate to large quantities of nonsaline water to wells near the outcrop area, especially in east Texas where yields of about 500 gpm are common. In discussing ground water in the Lufkin area, White, Sayre, and Heuser (1941, p. 29) report that an abundant supply of water probably could be obtained from the Sparta, but that the water is too highly mineralized for municipal or most industrial uses. A similar situation probably exists elsewhere in east Texas, and it is probable that the Sparta

is a potential source of large quantities of saline water in areas where supplies of fresh water are limited.

The observed dissolved-solids content in saline water from the Sparta sand ranges from 1,030 to 2,090 ppm. The locations of wells tapping the Sparta and the analyses of water from the Sparta are shown in plate 5 and table 1, respectively.

UPPER PART OF CLAIBORNE GROUP AND JACKSON GROUP, UNDIFFERENTIATED

For purposes of discussion, the remaining Eocene aquifers are undifferentiated. These include the Cook Mountain and Yegua formations of the Claiborne group and the formations of the Jackson group. These strata crop out in a belt extending from the Sabine River in Sabine County westward to Houston and Trinity Counties, thence southwestward to La Salle and McMullen Counties where the outcrop swings to the south, reaching the Rio Grande in Webb and Zapata Counties and western Starr County (pl. 5). The formations all dip gently toward the coast.

The upper part of the Claiborne and the Jackson consist principally of medium- to fine-grained sand and clay. The individual sand bodies are for the most part lenticular and not continuous over long distances. These formations are relatively unimportant as aquifers in Texas. In some places, however, they yield small to moderate quantities of water to public-supply and irrigation wells. According to Lonsdale and Day (1937, p. 53) the Cook Mountain formation is an important source of water for domestic use and irrigation in Webb County and is a potential source for additional irrigation water.

The chemical analyses of water from the upper part of the Claiborne group and the Jackson group, undifferentiated, are shown in table 1. The water from these aquifers is of the sodium chloride type. In some samples sodium constitutes 99 percent of the cations. The observed dissolved-solids concentration of the selected water samples ranges from 1,170 ppm in water from the Yegua formation to 25,900 ppm in water from the Jackson group. The locations of the spring and wells sampled are shown in plate 5.

MIOCENE AND MIOCENE(?) SERIES

CATAHOULA SANDSTONE, OAKVILLE SANDSTONE, AND LAGARTO CLAY, UNDIFFERENTIATED

For purposes of discussion, the Catahoula sandstone of Miocene(?) or Miocene age, the Oakville sandstone of Miocene age,

and the Lagarto clay of Miocene(?) age are undifferentiated. Although the Catahoula sandstone in most places is easily distinguished from the overlying Oakville, it is included with the Oakville and Lagarto because in many places wells tap both the Catahoula and the Oakville and mixed water is obtained. The Lagarto clay is included with the Catahoula and Oakville because in east Texas, especially, it is difficult to differentiate the Lagarto and Oakville.

The Catahoula, Oakville, and Lagarto formations crop out in a broad belt extending from the Sabine River in Sabine and Newton Counties generally westward to Walker County; thence the outcrop swings more to the southwest, lying roughly parallel to the coast, to McMullen County and northern Duval County. Here the Lagarto and Oakville are overlapped by the Goliad sand, but the Catahoula continues to crop out in a narrow band extending southward to the Rio Grande in Starr County (pl. 6).

These formations consist principally of sand and clay, although the Catahoula contains a considerable quantity of pyroclastic material, especially in south Texas, where it is known as the Catahoula tuff. The sand of the Catahoula is usually light in color and medium to coarse grained in texture. In places the sand of the Catahoula is cemented with silica to form quartzite. The unit formed by the Oakville and Lagarto is predominantly sandy in the lower part, clayey in the upper part. The sand of the Lagarto usually is finer grained than that of the Oakville or Catahoula, and the individual sand beds are usually thinner.

The sand of the Catahoula, Oakville, and Lagarto yields small to moderate supplies of fresh water to wells on and near the outcrop. Yields of 750 gpm from the Catahoula have been reported at Cuero in De Witt County. Similar yields from wells tapping the Catahoula and Oakville have been obtained at Huntsville in Walker County. The sand of the Oakville and Lagarto probably contributes to the deeper wells in the Houston area; however, the sand of the Catahoula probably contains saline water. The water from these formations is mostly of the sodium chloride type, the observed dissolved-solids content of saline water ranging from 1,020 ppm in Jim Hogg County to 17,500 ppm in Starr County.

According to Follett, White, and Irelan (1949, p. 9) many irrigation wells producing from these formations in the Linn-Faysville area in Hidalgo County yield water that contains boron in excess of the safe limits for citrus trees, as suggested by the U. S. Department of Agriculture. The concentration of boron averages 4.0 ppm in 26 wells in the Linn-Faysville area, ranging in depth from 631 to 2,050 feet. One stock well in Starr County, 381 feet deep, yields water containing 13 ppm of boron from the Catahoula.

Analyses of water from the Catahoula sandstone, Oakville sandstone, and Lagarto clay are shown in table 1. The locations of the wells from which samples were obtained are shown in plate 6.

PLIOCENE SERIES

OGALLALA FORMATION

The Ogallala formation of Pliocene age lies as a relatively continuous deposit at the surface of the High Plains of Texas (fig. 11). The Ogallala consists principally of sand, gravel, silt, clay, and, in some places, caliche. The formation has one of the highest yields of the aquifers in Texas. It supplies large quantities of water to irrigation wells, especially in the area south of the Canadian River where yields of 1,000 gpm are common. In most areas the water is of good quality; however, in the vicinity of some of the playa lakes the water is highly mineralized (Leggat, 1952, p. 17).

Water yielded to wells in the Ogallala is generally of the calcium bicarbonate and calcium sulfate types. Most of the wells in the Ogallala yield water containing some fluoride, and in some areas all the well waters are high in fluoride content.

The observed dissolved-solids content of saline water in wells in the Ogallala formation ranges from 1,010 to 17,400 ppm. Selected analyses of saline water from the Ogallala are shown in table 1. The locations of the wells from which the samples were taken are shown in figure 11.

TERTIARY AND QUATERNARY SYSTEMS

PLIOCENE, PLIOCENE(?), AND PLEISTOCENE SERIES

GOLIAD SAND, WILLIS SAND, AND LISSIE FORMATION, UNDIFFERENTIATED

The Goliad sand of Pliocene age, the Willis sand of Pliocene(?) age, and the Lissie formation of Pleistocene age are undifferentiated for purposes of discussion in this report. The sequence crops out in a wide belt roughly parallel to the coast extending from the Sabine River in Newton County generally westward to the Trinity River, thence the outcrop swings more to the southwest and eventually to the south in south Texas (pl. 7). The formations dip toward the coast and thicken coastward. They consist of a thick series of largely unconsolidated sand, gravel, silt, and clay.

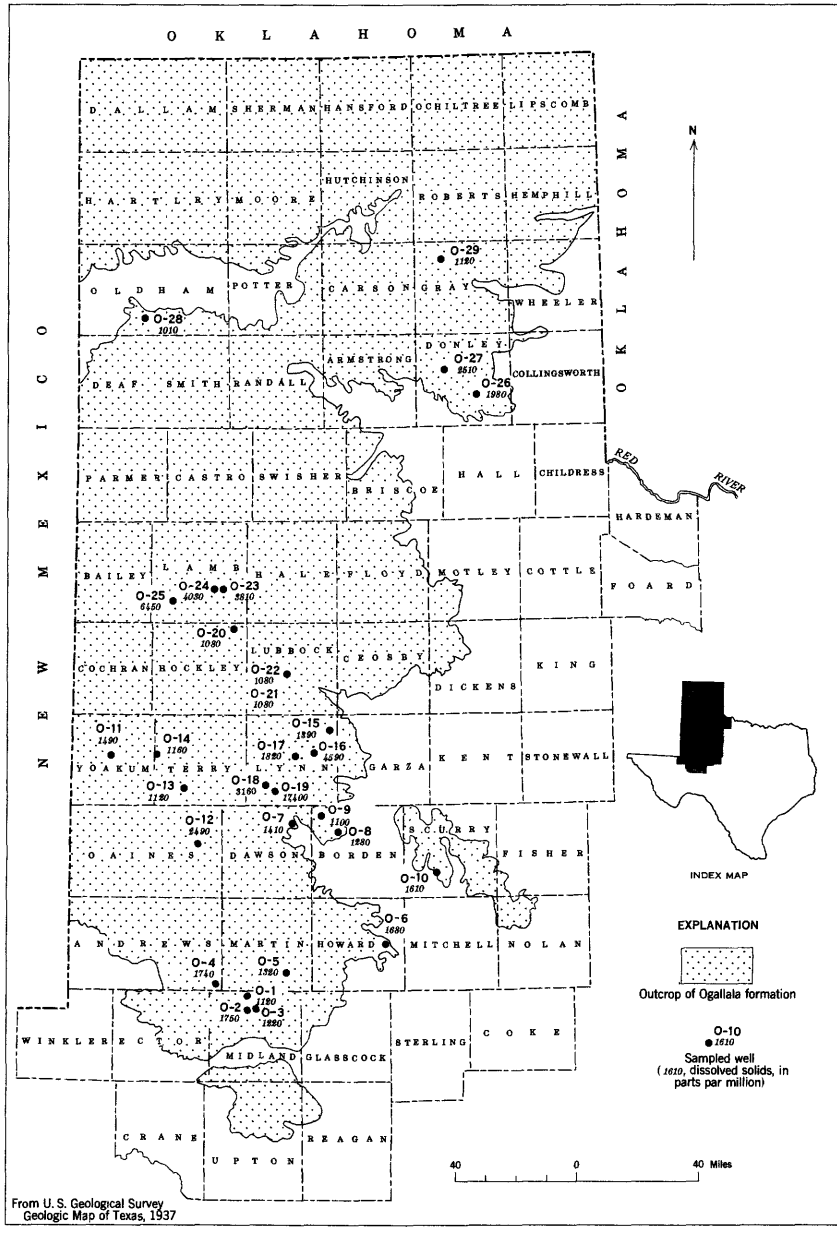


Figure 11.—Map showing locations of wells sampled and areas of outcrop of the Ogallala formation.

The sand of the Goliad, Willis, and Lissie probably constitutes the greatest potential source of ground water in Texas. It supplies large quantities of water to municipal and industrial supply wells in the Houston area. It is also used as a source of supply for the irrigation of rice throughout a large area on the upper gulf coast. Many of the wells in the upper gulf coast area have yields in excess of 2,000 gpm. In this area the upper sand, the Lissie, has the highest yield, whereas in south Texas most of the water comes from the Goliad sand. It is probable that these formations could yield large quantities of saline water in a narrow belt along the coast where only comparatively small supplies of good water are available. Locations of saline-water wells tapping this sequence are shown in plate 7.

Water from the Goliad sand, Willis sand, and Lissie formation varies greatly from place to place in concentration of dissolved solids. Observed concentrations of saline water range from 1,000 to 7,190 ppm in dissolved solids in San Patricio County and Starr County, respectively. The water is of the sodium chloride type.

Water from the Goliad sand in Cameron, Hidalgo, and Starr Counties contains excessive concentrations of boron. The water pumped from one well in Starr County contained 14 ppm of boron. Analyses of saline water from these formations are shown in table 1.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

BEAUMONT CLAY

The Beaumont clay of Pleistocene age crops out in a wide belt adjoining the coast and extending from the Sabine River to the Rio Grande (pl. 7). The formation dips toward the coast and is known to extend out beneath the shoreward part of the Continental Shelf. The formation consists largely of clay but has a few thin layers of fine sand. In an area along the upper coast in Brazoria, Galveston, Harris, Chambers, Jefferson, and Orange Counties, a thick bed of very permeable sand, known locally as the Alta Loma sand, occurs at the base of the Beaumont.

The sands of the Beaumont clay supply small to moderate quantities of water to many industries and to public supplies along the coast. The "Alta Loma" sand yields large quantities of water, especially in Galveston County and southeastern Harris County, where yields of about 2,000 gpm are obtained from wells. In the imme-

diate vicinity of the coast the "Alta Loma" contains saline water. Much of this water is used for industrial cooling purposes.

The Beaumont clay on the whole may be considered a potential source of small supplies of saline water near the coast. Where the "Alta Loma" sand is present, large quantities of water are generally available. Locations of wells furnishing saline water from the Beaumont clay are shown in plate 7. Slightly saline water from a well tapping the Beaumont clay at the Bergstrom Air Force Base on Matagorda Island is being demineralized by an ion-exchange process. This is one example of how saline water can be used for domestic purposes after treatment for removal of objectionable amounts of dissolved minerals. Analyses of the water before and after demineralization (sample B–7) are shown in table 1.

The water from the Beaumont clay is of the sodium chloride type. The observed dissolved-solids concentration of saline water from the Beaumont ranges from 1,060 ppm in Chambers County to 8,410 ppm in Kleberg County. The chemical analyses of saline water from the Beaumont clay are shown in table 1.

PLEISTOCENE AND RECENT ALLUVIAL, EOLIAN, AND LITTORAL DEPOSITS

Thin beds of alluvial material overlie the older formations in many parts of Texas. Locally these deposits are thick enough and so situated that they form aquifers of considerable importance.

Probably the most important alluvial aquifers are the bolson deposits in trans-Pecos Texas. Thick bolson deposits in the El Paso area and in Hudspeth and Culberson Counties furnish large quantities of water to wells. Yields up to 1,000 gpm are common in the El Paso area. Recent test drilling near El Paso has shown that large quantities of saline water are available below the fresh water and in places within the fresh-water zone in that area.

Alluvial deposits in the vicinity of the Pecos River valley are an important source of water. Large quantities of water are pumped from wells tapping the alluvial deposits, especially in Pecos and Reeves Counties where yields of more than 1,000 gpm are common. Many of the wells yield saline water which is used for irrigation.

Another area of large-scale production of water from alluvial materials is the lower Rio Grande valley. In Cameron and Hidalgo Counties many irrigation wells draw moderately saline water from the alluvium of the Rio Grande. Yields of about 2,100

gpm are reported in Cameron County (Dale and George, 1954, p. 11).

In the central part of the Osage Plains region, a thin, discontinuous layer of alluvial material overlies the red beds of Permian age and occupies the surface in parts of Childress, Hardeman, Wilbarger, Foard, Knox, Baylor, Haskell, Throckmorton, Stonewall, Fisher, and Jones Counties. Locally the alluvium has a sufficient saturated thickness to be a source of water for small-scale irrigation and public supply. In most places the water is of good quality; but in others it is highly mineralized.

In many places in Texas, water is obtained from surficial alluvial or sand-dune deposits, but most of these supplies are very small. Locally, small supplies of water are obtained from beach- and dune-sand deposits along the coast. Along some of the streams small quantities of water are pumped from the alluvium in the stream bottoms or from terrace gravels along the streams.

Locations of wells tapping saline water in Pleistocene and Recent deposits are shown in plate 8, and analyses of well waters in several sections of Texas are shown in table 1. The chemical characteristics of the water from these deposits is contingent upon several factors: the nature of the material, rainfall in the area, thickness of the deposits, quality of the water recharging the deposits, and natural flushing of the deposits.

On the basis of the available analyses, a general statement can be made concerning the chemical quality of the water from these deposits. Although alluvial deposits are found in many places throughout the State in different geologic settings, the water is generally of the sodium chloride and calcium sulfate types. The observed concentration of dissolved solids in the saline water ranges from 1,020 ppm in water from the alluvium in Cameron County to 11,800 ppm in water from the alluvium in El Paso County.

Water of good quality is yielded to some municipal supply wells in the Pleistocene and Recent deposits. However, in the absence of water of better quality, many cities use water classified as saline from these deposits.

Boron in concentrations as high as about 4 ppm was found in water from the alluvium in Starr County.

SALINE SURFACE WATER

Movement of surface water is generally much faster than ground water; hence, surface water is less likely to become saline than ground water. However, water in streams or lakes often becomes saline by concentration resulting from surface evaporation of lakes (most common in closed basins); solution of the readily soluble mineral salts present in the rocks over which the stream flows (many streams in west Texas pass over rocks of Permian and Triassic age that contain evaporites exposed at the surface); discharge of saline ground water into effluent streams (fig. 12); intrusion of sea water into coastal streams (often caused by large withdrawal of surface water near the coast; and contamination of streams by man (such as the disposal of oilfield brines into the stream channels).

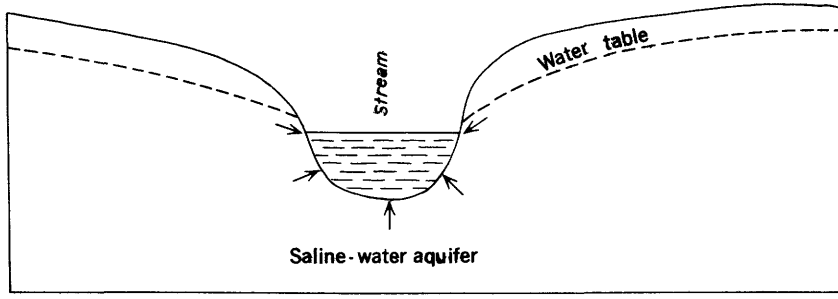


Figure 12. —Typical effluent stream receiving saline water.

In some streams, during the initial rise in stage in a flood, the dissolved-solids content of the water increases because of the solution of mineral salts present in the sediments disturbed by the scouring action of the water. After this first increase in dissolved solids the water often becomes more dilute, reflecting the chemical quality of the floodwater from gullies, other drainageways, and fields. In many streams in Texas the day-to-day quality of the water has been improved by the construction of dams regulating streamflow and impounding the dilute flood flows with the more concentrated low flows. Although saline waters have been found now and again in streams in all parts of Texas, the areas in which saline waters are present for extended periods are rather limited. Only those basins for which saline-water data were available are discussed. The approximate boundaries of the major river basins and the locations of sampling points at which saline surface water have been found are shown in plate 9. Saline

surface water occurs most commonly in west and northwest Texas where the rocks at the surface contain easily soluble minerals. Low rainfall and high rates of evaporation also are factors contributing to the presence of saline surface water in this area. Another area where many streams contain saline water is along the gulf coast. Here sea water intrudes the tidal reaches of some of the streams in some areas, in part because of large withdrawals of fresh water for irrigation or industrial use.

The U. S. Geological Survey, working in cooperation with the Texas Board of Water Engineers, has analyzed many thousands of samples of water from Texas streams. Because of the many data available and because this is a reconnaissance report, not all the available analyses of saline surface water in Texas are listed here. Maximum, minimum, and weighted-average analyses for representative years, data on the mean discharge of streams, and other pertinent data are shown in tables 3 and 4, respectively. A weighted-average analysis represents the approximate chemical composition of all the water passing a certain sampling station in 1 year if impounded with thorough mixing in a reservoir, and neglecting evaporation and rainfall. In this report, for clarity, the occurrence of saline surface water is discussed by river basins.

CANADIAN RIVER BASIN

The Canadian River, a tributary of the Arkansas River, flows 190 miles in an easterly direction across the Texas Panhandle (pl. 9). Almost 25 percent of the entire length of the river lies in Texas. The area of the drainage basin in Texas is about 9,700 square miles.

Chemical-quality data have been collected at regular sampling stations on the Canadian River at Tascosa, near Amarillo, and near Borger, and samples from miscellaneous points in the basin have been collected at various times.

Water from the Canadian River stations shows a considerable variation in concentration of dissolved solids. Although the water generally is slightly saline during periods of low flow, weighted-average analyses show that a reservoir proposed for construction at Sanford would impound a mixture of water that would not be saline. Some samples of the river water at Borger have been slightly to moderately saline, and it is probable that some saline water occurs at times in the Canadian River all the way across the panhandle. Perhaps some of this salinity is in part due to pollution from the large panhandle oilfield.

Locations of sampling points and analyses of saline water from the Canadian River basin are shown in plate 9 and table 3, respectively.

RED RIVER BASIN

The Red River is formed by the junction of several small streams rising in the southeastern part of the Texas Panhandle (pl. 9). The Prairie Dog Town Fork drains the largest area and is considered the upstream continuation of the main stem. The Red River forms the boundary between Oklahoma and Texas and Arkansas and Texas. The area of the basin is 4,580 square miles at the Texas-Arkansas State line. The principal tributaries to the Red River in Texas are the Sulphur, Big and Little Wichita, and Pease Rivers and the Salt and North Forks of the Red River.

The upper tributaries of the Red River cross Triassic and Permian formations which contain much readily soluble material. The Salt Fork of the Red River and Mulberry Creek contain relatively high concentrations of calcium sulfate derived from gypsum. A proposed reservoir on the Prairie Dog Town Fork of the Red River was dropped from consideration because of the high salinity of the water which would be impounded. The Pease River is high in both sulfate and chloride content. Lake Kemp on the Big Wichita River was originally built for irrigation purposes but the salinity of the impounded water limited its use for this purpose. Flood flows stored behind Denison Dam in Lake Texoma have diluted the saline inflow so that the impounded water is seldom saline. However, at Gainesville above the reservoir the river water is moderately saline for long periods.

Some salinity due to salt from the Talco oilfield is found in the Sulphur River during low flows. Salinity due to oil operations occurs in other areas in the Red River basin, particularly near Wichita Falls.

Locations of the sampling points and analyses of saline water in the Red River basin are shown in plate 9 and table 3, respectively.

BRAZOS RIVER BASIN

The Brazos River, which drains an area of 35,400 square miles, is one of the principal intrastate streams in Texas. The Salt Fork and the Double Mountain Fork join to form the Brazos River in the northeastern part of Stonewall County (pl. 9), and the river then

flows generally southeastward, emptying into the Gulf of Mexico near Freeport in Brazoria County.

The low flows of the Salt Fork frequently are very saline, but some high flows are fresh. However, weighted-average analyses show that the water is moderately saline. The Double Mountain Fork is fresh during high flows; its low flows are moderately saline, and the weighted-average analyses show the water to be slightly saline. Water from the Clear Fork of the Brazos River is generally fresh, but at times it is slightly to moderately saline. A mixture of the water from the three main tributaries is stored in the Possum Kingdom Reservoir. Water released from the reservoir is slightly saline, and inflow to the Whitney Reservoir downstream is sometimes slightly saline. Formerly, saline water traveled to the mouth of the Brazos River, but since the completion of the Whitney Dam the water has been fresh from Whitney Dam to the mouth of the river, except when oilfield brines are released to minor tributaries entering the river downstream from the dam.

Miscellaneous samples from Colony Creek, tributary to the Leon River in Eastland County, show the water to be moderately saline to very saline. Oilfield brines have been released to this creek from time to time, causing the observed salinity. It is probable that some other small streams in the Brazos watershed are similarly affected.

Sampling points and analyses of the water in the Brazos River basin are shown in plate 9 and table 3, respectively.

COLORADO RIVER BASIN

The Colorado River rises in Dawson County at the eastern edge of the High Plains and flows in a southeasterly course across the State, finally discharging into Matagorda Bay (pl. 9). The contributing area is 29,730 square miles.

The Colorado River is sometimes saline above Colorado City, owing to the discharge of salt springs from the Permian and Triassic formations in the riverbed. Slight salinity has been observed at Robert Lee also. In general, salinity concentrations are lower in the upper reaches of the Colorado than in the upper Brazos watershed. Before construction of the dam forming Lake Colorado City, Morgan Creek often was slightly to moderately saline. The impounded water, however, has always been fresh. Other tributaries of the upper Colorado contain saline water during low flows but are fresh during flood flows.

Sampling points in the Colorado River basin and analyses of the water are shown in plate 9 and table 3, respectively.

RIO GRANDE BASIN

The Rio Grande rises in the San Juan Mountains in southwestern Colorado, flows in a general southerly direction across New Mexico, and then turns southeastward, forming the international boundary between the United States and Mexico and enters the Gulf of Mexico near Brownsville, Tex. (pl. 9). The Rio Grande in the United States has a drainage area of about 89,000 square miles.

The salinity of the Rio Grande increases downstream to the upper Presidio station, where the water is moderately saline at times. Below this station the water has been saline at times all the way to the mouth. Recent completion of the Falcon Dam at the Zapata-Starr County line makes it likely that saline water will no longer occur below the dam except in tidal reaches. The International Boundary and Water Commission operates sampling stations on the Rio Grande and its tributaries. Analyses of saline water from the Rio Grande at El Paso, the station at Fort Quitman, and the upper Presidio station, made by the United States section of the International Boundary and Water Commission (1950), are shown in table 3.

Tributary inflow to the Rio Grande in Texas is generally small and moderately to very saline. The Pecos River, principal tributary to the lower Rio Grande, rises in the Sangre de Cristo Mountains in New Mexico and enters Texas at the Loving-Reeves County line. The Pecos in Texas flows about 260 miles in a southeasterly direction and joins the Rio Grande in Val Verde County (pl. 9).

Red Bluff Dam on the Pecos River just below the Texas-New Mexico State line, completed in 1936, has a storage capacity of 307,000 acre-feet. The quality of the stored water varies, depending on the conditions of discharge into the reservoir. In March 1953 the water discharged from the reservoir was moderately saline (table 3).

Pecos River water near Orla ranges from slightly saline to moderately saline. Below Grandfalls the river water frequently is very saline, owing to return flow of irrigation water which is moderately to very saline when applied.

Locations of samples and analyses of the water in the Rio Grande basin are shown in plate 9 and table 3, respectively.

SALINE LAKES AND RESERVOIRS

Saline water is found in both natural lakes and in artificial reservoirs in Texas. Natural lakes are saline primarily because of concentration by evaporation at the surface. Water in artificial reservoirs may be saline either because of concentration by evaporation or because the impounded stream is fed by saline water. The day-to-day quality of the water in the downstream reaches of a normally saline stream is generally improved by impoundment that permits mixing of the fresh water of high flows with the saline water of low flows.

Natural lakes containing saline water are found in the High Plains, Pecos Valley and trans-Pecos, and Osage Plains regions in Texas. The "Salt Flats," a chain of lakes in Hudspeth County in the Dell City area, illustrate the high salinity typical of closed basins. According to Scalapino (1950, p. 2), the basin is a depression about 150 miles long and 5 to 15 miles wide. It contains a large number of shallow lakes and salt-encrusted flats and is fed by the Sacramento River, which flows only after heavy rains. It is reported that surface flows seldom reach the lowest part of the basin.

Playa basins in central Lynn County contain water-table lakes which occupy depressions created by wind erosion and solution and differential compaction in the underlying Ogallala formation (Leggat, 1952). An analysis shows that the water from Toyah Lake in Reeves County is very saline. Waters from Cedar Lake in Gaines County and Rich Lake in Terry County are classed as brines. The amount of dissolved solids in the waters is about 90,000 ppm.

Artificial reservoirs for which chemical analyses are available include Daniel Salt Lake in Eastland County, whose water contains 136,000 ppm of dissolved solids. This reservoir is on Colony Creek, which is a tributary of the Leon River. Its salinity is due to inflow of saline water from oilfields. Lake Kemp on the Wichita River in Baylor County and Lake Texoma on the Red River in Cooke and Grayson Counties are slightly saline. Lake Balmorhea, also known as Lower Parks Reservoir, is fed by springs on Toyah Creek in Reeves County. It contained slightly saline water in January 1950. Red Bluff Lake in Loving County, formed by impounding water from the Pecos River, normally contains about 7,000 ppm of dissolved solids. Chemical analyses of saline lakes and reservoirs in Texas are shown in table 3.

SALINITY IN TIDAL REACHES OF STREAMS, BAYS, AND ESTUARIES

Saline water is present in the tidal reaches of the streams that empty into bays and estuaries along the gulf coast. Generally the salinity of the river water thus affected is less than that of sea water. In some places large withdrawals of river water for industrial and irrigation use have caused the heavier, more concentrated sea water to form a "wedge" which gradually invades the fresh-water reaches of the streams along the bottoms of the stream channels.

Examples of salinity caused by the intrusion of sea water are provided by the analyses of water from the Trinity River at Anahuac and Old River near Cove (table 3). The water at these two stations ranges from fresh to very saline.

The concentration of dissolved solids in the water in bays and estuaries along the gulf coast of Texas is represented by the analysis of sample 37 (table 3). This sample of the water from Laguna Madre was taken near Riviera, Tex., at the Carolina Beach pier and is classified as a brine.

CONCLUSION

Saline water is widely distributed in the underground reservoirs, streams, and lakes of Texas. In north-central and west Texas, in large areas where no potable water is found, the water ranges from slightly saline to brine. In these areas an economic demineralization would be most helpful.

LITERATURE CITED

Broadhurst, W. L., 1950, Ground-water resources of Gregg County, Tex.: U. S. Geol. Survey Water-Supply Paper 1079–B.

Dale, Oscar C., and Broadhurst, William L., 1953, Memorandum on ground-water irrigation in Mitchell County, Tex.: Tex. Board Water Engineers.

Dale, Oscar C., and George, William O., 1954, Ground-water resources of Cameron County, Tex.: Tex. Board Water Engineers Bull. 5403.

Follett, C. R., White, W. N., and Irelan, Burdge, 1949, Occurrence and development of ground water in the Linn-Faysville area, Hidalgo County, Tex.: Tex. Board Water Engineers.

International Boundary and Water Commission, United States and Mexico, 1950, Flow of the Rio Grande and related data, Water Bull. no. 20, Dept. of State.

———1951, Flow of the Rio Grande and related data, Water Bull. no. 21, Dept. of State.

Knowles, D. B., and Lang, J. W., 1947, Preliminary report on the geology and ground-water resources of Reeves County, Tex.: Tex. Board Water Engineers.

Leggat, E. R., 1952, Geology and ground-water resources of Lynn County, Tex.: Tex. Board Water Engineers Bull. 5207.

Livingston, Penn P., 1942, A few interesting facts regarding the natural flow from artesian well 4 owned by the San Antonio Public Service Co., San Antonio, Tex.: U. S. Geol. Survey, duplicated release.

Livingston, Penn P., Sayre, A. N., and White, W. N., 1936, Water resources of the Edwards limestone in the San Antonio area, Tex.: U. S. Geol. Survey Water-Supply Paper 773–B.

Lonsdale, J. T., and Day, J. R., 1937, Geology and ground-water resources of Webb County, Tex.: U. S. Geol. Survey Water-Supply Paper 778.

Plummer, F. B., and Sargent, E. C., 1931, Underground waters and subsurface temperatures of the Woodbine sand in northeast Texas: Univ. Texas Bull. no. 3138.

Richards, L. A., and others, 1954, Diagnosis and improvement of saline and alkali soils: U. S. Dept. Agr. Handbook 60.

Scalapino, Ralph A., 1950, Development of ground water for irrigation in the Dell City area, Hudspeth County, Tex.: Tex. Board Water Engineers Bull. 5004.

Sellards, E. H., Adkins, W. S., and Plummer, F. B., 1932, The geology of Texas: Univ. of Texas Bull. no. 3232, v. 1.

Smith, Otto M., Dott, Robert H., and Warkentin, E. C., 1942, The chemical analyses of the waters of Oklahoma: Okla. A & M Coll., Div. Eng. Pub. No. 52, v. 12, p. 15.

Sundstrom, R. W., Broadhurst, W. L., and Dwyer, B. C., 1949, Public water supplies in central and north-central Texas: U. S. Geol. Survey Water-Supply Paper 1069, p. 81.

United States Public Health Service, 1946, Drinking water standards: Public Health Reports, v. 61, no. 11, p. 371–384.

White, Walter N., Gale, Hoyt S., and Nye, Spencer S., 1941, Geology and ground-water resources of the Balmorhea area, western Texas: U. S. Geol. Survey Water-Supply Paper 849–C

White, Walter N., Sayre, A. N., and Heuser, J. F., 1941, Geology and ground-water resources of the Lufkin area, Tex.: U. S. Geol. Survey Water-Supply Paper 849–A.

Willis, Gordon W., 1954, Ground-water resources of Tom Green County, Tex.: Tex. Board Water Engineers Bull. 5411.

TABLES OF BASIC DATA

Table 1.—*Chemical analyses and related physical*

[Analyses in parts per million,

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Hickory sandstone member
CO-1	Concho	25	0.05	5.9	2.2	417	19	438
								Ellenburger
CO-2	San Saba	1.7	.....	96	71	2,270		180
CO-3	Crockett	.....	.....	1,116	262	15,486		708
CO-4	Reagan	.....	.....	18,900	8,290	22,900		25
CO-5	Ector	.....	.....	2,668	757	27,221	.....	702
CO-6	Ector	.....	.....	849	364	14,510		397
CO-7	Andrews	.....	.....	1,256	533	14,311		870
CO-8	Andrews	.....	.....	2,852	685	21,073	.....	232
CO-9	Andrews	.....	.....	20,972	3,642	70,198		49
CO-10	Scurry	.....	.....	2,476	617	19,964		293
								Pennsylvanian
C-1	McCulloch	15	.....	14	7.1	384		409
C-2	McCulloch	15	.....	17	8.7	388		403
C-3	Wise	.....	.....	230	98	166		536
C-4	Parker	3.8	.....	6.1	3.2	841		507
C-5	Palo Pinto	.....	.....	200	158	974		606
C-6	Parker	7.2	0.16	87	46	2,730		293
C-7	Parker	9.0	.02	401	637	2,550		156
C-8	Lampasas	.....	.....	2,710	1,010	28,400		327
C-9	Archer	12	.....	36	14	1,910		492
C-10	Montague	13	.47	6.6	1.9	557		636
C-11	Montague	11	16	4.6	1.4	481	5.8	698
C-12	McCulloch	.....	.....	.....	.....	.....		116
C-13	Eastland	11	.....	14	3.7	757		481
C-14	Burnet	13	.....	1,010	665	10,200		173
								Bone Spring
P-1	Hudspeth	19	.....	251	97	89		248
P-2	Hudspeth	16	.....	213	79	25		260
P-3	Hudspeth	14	.....	254	99	192		236
P-4	Hudspeth	18	.....	170	90	99		252
								Delaware
P-5	Culberson	14	.....	.....	.....	.....		.....
P-6	Reeves	.....	.....	7,680	1,950	90,800		33
P-7	Loving	.....	.....	7,000	1,520	35,700		46
								Wichita and
P-8	Tom Green	11	.....	904	340	431		308
P-9	Tom Green	5.2	.....	408	192	250		100
P-10	Tom Green	21	.....	454	162	246	.....	258
P-11	Tom Green	23	.....	254	101	189	.....	237
P-12	Runnels	15	0.11	204	85	133	6.2	312
P-13	Taylor	16	18	190	49	100	6.7	288
P-14	Taylor	21	.06	464	90	209	12	245
P-15	Jones	.....	.15	592	91	278	.....	256

measurements of saline ground water in Texas

except as indicated]

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
of Riley formation										
.....	23	400	2.6	0.5	1.3	1,110	24	95	2,040	8.0
group										
.....	42	3,740	.....	.....	.....	6,310	532	90	11,200	7.9
.....	2,850	24,050	.....	.....	.....	45,800	.....	.....	.....	7.5
.....	1,020	92,100	.....	.....	.....	143,000	.....	38	127,300	.....
.....	2,640	46,600	.....	.....	.....	85,800	.....	.....	.....	7.8
.....	48	24,700	.....	.....	.....	45,480	.....	.....	.....	7.8
.....	1,375	24,350	.....	.....	.....	44,140	.....	.....	.....	7.5
.....	2,640	37,500	.....	.....	.....	69,550	.....	.....	.....	7.7
.....	100	156,100	.....	.....	.....	286,700	.....	.....	.....	5.9
.....	1,940	35,400	.....	.....	.....	63,000	.....	.....	.....	7.2
undifferentiated										
.....	19	385	.....	0.5	.....	1,030	64	93	1,930	8.2
12	14	400	.....	3.0	.....	1,050	78	91	1,960	8.4
.....	781	61	.....	.0	.....	1,600	977	27	.....	.....
55	774	418	.....	. 1.8	.....	2,320	28	98	3,640	8.9
.....	2,310	260	.....	1.2	.....	4,200	1,150	65	.....	.....
.....	4.6	4,320	.....	16	.....	7,360	406	94	12,700	7.2
.....	4,530	3,010	.....	90	.....	11,300	3,620	61	14,400	7.2
.....	129	51,200	.....	.....	.....	83,600	10,900	85	108,000	.....
20	216	2,590	.....	.....	.....	5,030	148	97	8,760	.....
.....	44	465	4.4	1.8	.....	1,410	24	98	.....	8.0
38	53	286	3.0	1.2	.....	1,210	18	98	2,160	8.4
37	10	3,310	.....	.....	.....	5,640	.....	.....	.....	9.2
.....	2.5	922	.....	.5	0.82	1,950	52	97	3,560	7.9
.....	129	19,200	.....	.....	3.2	31,300	5,260	81	48,100	7.5
limestone										
.....	798	130	.....	2.2	.....	1,510	1,030	16	2,050	.....
.....	624	32	.....	2.8	.....	1,120	856	6	1,470	.....
.....	845	268	.....	8.5	0.54	1,800	1,040	28	2,480	7.5
.....	608	118	.....	3.8	.....	1,230	794	21	1,750	.....
Mountain group										
.....	632	922	.....	.....	.....	>1,000	140	.....	6,370	7.9
.....	546	159,000	.....	.....	.....	260,000	27,200	88	235,000	.....
.....	1,550	70,100	.....	.....	.....	116,000	.....	.....	.....	.....
Clear Fork groups										
.....	1,470	1,990	.....	3.5	.....	5,300	3,650	20	7,810	.....
.....	1,930	185	.....	.0	.....	3,020	1,810	23	3,480	.....
.....	1,760	185	.....	.0	0.71	2,960	1,800	23	3,460	7.8
.....	1,060	126	.....	1.8	.65	1,870	1,050	28	2,470	8.0
.....	584	201	1.8	5.2	.....	1,390	858	25	2,040	7.4
.....	545	56	1.0	20	.....	1,130	676	24	1,570	7.2
.....	1,410	161	.8	123	.....	2,610	1,530	23	3,160	7.2
.....	1,590	391	.8	49	.....	3,450	1,850	25	.....	7.5

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Wichita and Clear
P-16	Jones	16	0.00	60	61	720	3.0	261
P-17	Jones	16	.00	282	80	204	15	189
P-18	Jones	17	.00	314	118	262	3.6	222
P-19	Jones	14	.....	556	260	1,270		205
P-20	Jones	19	.22	255	83	149	3.4	124
P-21	Jones	16	.19	282	80	204	15	189
P-22	Knox	.....	.....	.....	.....	....		224
P-23	Baylor	31	.02	154	76	596	6.0	543
P-24	Baylor	.....	.....	.....	.....	....		357
								San Angelo
P-25	Tom Green	8.6	.....	2,460	1,050	16,000		405
P-26	Coke	.....	.....	.....	.....	....		.....
P-27	Coke	16	.....	169	402	395		476
P-28	Nolan	10	.....	177	109	107		330
P-29	Jones	8.9	7.8	510	97	887		116
P-30	Jones	17	.28	880	371	1,140		314
P-31	Jones	18	.00	616	98	91	4.4	258
P-32	Stonewall	.....	.....	595	199	486		186
P-33	Stonewall	.....	.....	.....	.....	....		50
P-34	Foard	.....	.....	652	243	959		110
P-35	Hardeman	.....	.....	484	214	1,070		73
P-36	Hardeman	.....	.....	611	262	288		281
P-37	Hardeman	.....	.....	515	161	383		256
P-38	Hardeman	.....	.....	.....	.....	.....		244
								Blaine
P-39	Jones	17	0.00	546	184	227		176
P-40	Fisher	.....	.....	558	147	404		112
P-41	Stonewall	15	.....	812	164	469		52
P-42	Cottle	.....	.....	534	144	337		232
P-43	Hardeman	.....	.....	610	100	145		207
P-44	Hardeman	.....	.....	486	104	145		146
P-45	Hardeman	19	.....	.....	.....	53	....	200
P-46	Hardeman	14	.....	592	101	39	....	191
P-47	Childress	17	.....	602	139	240	....	190
P-48	Childress	18	.....	606	73	50	....	236
P-49	Childress	18	.....	600	117	124	....	190
P-50	Childress	18	.....	604	151	260	....	162
P-51	Childress	18	.....	608	158	256	....	162
P-52	Childress	16	.....	620	232	730	....	220
P-53	Childress	17	.....	570	130	83	....	104
P-54	Childress	17	.....	608	101	116	....	223
P-55	Collingsworth	22	.....	600	91	32		225
P-56	Collingsworth	20	.00	574	87	38	3.6	110
								Rustler
P-57	Culberson	.....	.....	615	51	64		105
P-58	Culberson	.....	.....	677	166	92		141
P-59	Culberson	14	.....	178	68	105		270
P-60	Reeves	19	.....	600	285	504		112
P-61	Reeves	.....	.....	896	253	861		147
P-62	Reeves	.....	.....	599	218	46		143
P-63	Reeves	.....	.....	605	216	5.3		130

measurements of saline ground water in Texas—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	ness as $CaCO_3$	cent sodium	Specific conductance (micromhos at 25°C)	pH
Fork groups—Continued										
.....	736	725	1.0	1.2	5.5	2,460	400	79	3,940	8.0
.....	1,060	138	1.2	45	.....	1,940	1,030	30	2,490	7.6
.....	1,310	228	.8	6.9	2.3	2,370	1,270	31	3,120	7.6
.....	3,070	1,300	.8	17	.....	6,590	2,460	53	8,160	7.6
.....	882	208	.6	4.0	.....	1,670	978	25	2,250	7.9
.....	1,060	138	1.2	45	.....	1,940	1,030	30	2,490	7.6
.....	1,750	395	.....	4.2	.....	>1,000	2,190	.....	.....	.....
.....	524	640	1.4	129	.83	2,430	696	65	3,810	7.6
.....	.....	2,000	.....	.....	.....	>1,000	.....	.....	.....	.....
sandstone										
.....	3,180	29,500	.....	.....	.....	52,400	10,500	77	69,600	.....
.....	.....	30,000	.....	.....	.....	>1,000	.....	.....	69,200	.....
.....	1,560	624	.....	50	.....	3,450	2,080	29	4,690	.....
.....	640	130	.....	3.0	.....	1,340	890	21	1,860	.....
.....	2,860	372	0.9	1.0	.....	4,790	1,670	54	5,800	7.7
.....	1,740	1,870	2.8	1,840	.....	8,020	3,720	40	10,400	7.4
.....	1,430	285	.6	62	0.36	2,730	1,940	9	3,340	7.6
14	2,310	560	.....	.4	.....	4,250	2,300	31	.....	.....
.....	5,890	1,270	.....	.4	.....	>1,000	1,950	.....	.....	.....
.....	2,830	1,180	.....	.....	.....	5,930	2,630	44	.....	.....
.....	3,200	500	.....	.....	.....	5,500	1,780	49	.....	.....
.....	2,340	400	.....	.....	.....	4,040	2,610	19	.....	.....
.....	2,160	232	.....	.....	.....	3,580	1,950	30	.....	.....
.....	970	104	.....	.....	.....	1,740	.....	.....	.....	.....
gypsum										
.....	2,180	139	1.1	0.5	.....	3,380	2,120	19	3,820	7.5
.....	2,310	268	.....	1.0	.....	3,740	2,000	31	.....	.....
.....	1,620	1,410	.....	2.0	.....	4,520	2,700	27	6,280	6.9
12	1,370	730	.....	1.2	.....	3,240	1,920	28	.....	.....
.....	1,790	152	.....	.....	.....	2,900	1,930	14	.....	.....
.....	1,710	63	.....	.....	.....	2,580	1,640	18	.....	.....
.....	1,660	60	.....	5.9	0.38	>1,000	1,860	6	2,850	7.0
.....	1,680	55	1.2	7.0	.40	2,580	1,890	43	2,760	7.1
.....	1,890	360	.....	4.6	.93	3,350	2,070	20	3,890	7.4
.....	1,580	55	.....	31	.41	2,530	1,810	6	2,740	7.4
.....	1,770	185	.....	4.5	.62	2,910	1,980	12	3,250	7.5
.....	1,950	380	.....	3.2	1.2	3,450	2,130	21	4,030	7.5
.....	1,890	460	.....	7.2	.50	3,480	2,170	20	4,120	7.5
.....	2,400	1,040	.....	.2	4.7	5,150	2,500	39	6,490	7.5
.....	1,790	102	.....	12	.41	2,760	1,960	8	3,050	7.9
.....	1,710	162	.....	6.3	.90	2,830	1,930	12	3,190	7.4
.....	1,630	41	.....	3.0	.28	2,530	1,870	4	2,680	7.0
.....	1,610	54	.....	12	.12	2,450	1,790	4	2,730	7.7
limestone										
.....	1,640	51	.....	25	.....	2,700	.....	7	2,630	.....
.....	2,240	83	.....	4.0	.....	3,720	.....	8	3,650	.....
.....	639	46	.....	.0	.....	1,180	724	24	1,570	7.8
.....	2,540	730	.....	.2	.....	4,730	2,670	29	5,850	7.2
.....	1,780	2,250	.....	.....	.....	6,110	3,280	36	.....	.....
.....	2,230	37	.....	.....	.....	3,200	2,390	4	3,330	.....
.....	2,180	24	.....	2.5	.....	3,540	2,400	1	3,280	.....

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Rustler
P-64	Reeves	.....	.....	603	277	342		101
P-65	Ward	18	0.01	984	622	12,800	19	113
P-66	Crane	.....	.....	852	197	1,480		98
P-67	Pecos	.....	.....	566	199	12		66
P-68	Pecos	.....	.....	1,250	608	14,900		225
P-69	Pecos	.....	.....	835	359	9,450		26
P-70	Pecos	.....	.....	342	83	194		252
P-71	Pecos	.....	.....	327	83	184		141
								Quartermaster
P-72	Borden	5.0	.....	26	28	2,300		513
P-73	Fisher	.....	.....	330	109	80		345
P-74	Fisher	.....	.....	810	232	350		135
P-75	Stonewall	35	.....	983	201	2,400		215
P-76	Stonewall	26	.....	2,740	620	11,700		134
P-77	Dickens	.....	.....	.....	.....	.....		302
P-78	Motley	.....	.....	.....	.....	202		111
P-79	Motley	.....	.....	527	173	1,070		76
P-80	Motley	.....	.....	172	71	403		362
P-81	Hall	.....	.....	1,500	293	17,100		126
P-82	Hall	34	.....	550	411	394		227
P-83	Hall	44	.....	352	82	15	9.2	162
								Dockum
Tr-1	Ector	5.5	.....	210	134	2,150		228
Tr-2	Ector	8.5	.....	170	90	2,280		348
Tr-3	Ector	8.0	.....	9.7	6.2	692		596
Tr-4	Mitchell	20	.....	184	61	132		104
Tr-5	Mitchell	21	.....	362	118	200	.....	172
Tr-6	Mitchell	12	.....	56	56	1,800		226
Tr-7	Mitchell	15	.....	112	141	2,240		292
Tr-8	Mitchell	5.0	.....	169	88	2,820		291
Tr-9	Scurry	10	.....	84	43	1,990		411
Tr-10	Scurry	19	.....	502	322	188		388
Tr-11	Scurry	18	.....	506	298	520		361
Tr-12	Lynn	26	27	109	237	672		264
Tr-13	Floyd	8.7	.....	206	89	4,990	.....	398
Tr-14	Borden	56	.....	103	62	211		330
Tr-15	Borden	11	.....	46	21	835		218
Tr-16	Borden	10	.....	112	76	1,020		570
Tr-17	Mitchell	6.5	.....	129	64	2,190		356
Tr-18	Borden	7.2	.....	185	94	3,660		279
Tr-19	Borden	9.2	.....	679	341	5,390		214
Tr-20	Oldham	13	.2	22	12	434	6.0	806
Tr-21	Lubbock	8.4	.0	284	122	7,420		230
								Travis Peak
K-1	Comal	.....	.....	71	71	325		171
K-2	Comal	.....	.....	.....	.....	.....		317
K-3	Travis	.....	.....	168	149	110		352
K-4	Travis	.....	.....	459	121	24		354
K-5	Travis	12	.....	53	42	1,170		502
K-6	Lampasas	.....	.....	51	27	451		365
K-7	Bell	.....	.....	39	27	1,210		507
K-8	Bell	14	0.07	12	4.5	440		437

measurements of saline ground water in Texas—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
limestone—Continued										
.....	2,700	350	.....	.....	.....	4,320	2,640	22	4,980	.....
.....	4,920	19,300	1.7	.....	4.3	38,700	5,010	85	52,000	7.4
.....	2,190	2,660	.....	3.0	.....	7,420	2,940	52	10,540	.....
.....	2,090	18	.....	.75	.....	3,240	2,230	1	.....	.....
.....	4,940	23,200	.....	.....	.....	45,000	5,620	85	.....	.....
.....	5,100	13,300	.....	.....	.....	29,300	3,560	85	40,800	.....
.....	959	292	.....	.0	.....	1,990	1,200	26	.....	.....
8	960	308	.....	.5	.....	2,210	1,160	26	.....	.....
formation										
35	1,730	2,080	.....	0.5	.....	6,440	180	97	9,900	.....
.....	950	122	.....	3.8	.....	1,760	1,270	12	.....	.....
.....	1,780	1,220	.....	64	.....	4,520	2,980	20	.....	.....
.....	1,590	4,730	.....	.....	.....	10,000	3,280	61	15,100	7.1
.....	1,800	23,300	.....	.....	.....	40,300	9,360	73	51,300	6.9
16	1,200	552	.....	.....	.....	>1,000	.....	.....	.....	.....
.....	1,760	94	0.3	2.5	.....	2,710	1,620	.....	.....	.....
.....	3,020	815	.3	1.0	.....	5,650	2,030	53	.....	.....
.....	401	620	.....	10	.....	1,850	721	55	.....	.....
.....	4,190	26,700	.....	.....	.....	49,800	4,940	88	69,600	.....
.....	2,970	432	.....	39	.....	4,940	3,060	22	5,260	7.4
.....	1,080	15	.....	1.5	0.07	1,680	1,220	3	1,920	7.4
group										
.....	2,440	2,140	.....	.....	.....	7,190	1,080	81	.....	.....
.....	1,580	2,710	.....	.....	.....	7,010	794	86	.....	.....
.....	484	395	.....	4.2	.....	1,890	50	97	.....	.....
.....	492	220	.....	111	.....	1,270	710	29	1,960	.....
.....	1,480	103	1.8	.2	0.83	2,370	1,390	24	2,840	7.3
10	935	2,210	.....	3.5	.....	5,190	370	91	8,630	.....
.....	998	3,150	.....	.....	.....	6,800	860	85	11,100	.....
.....	1,650	3,510	.....	.....	.....	8,390	734	89	12,500	.....
20	1,700	1,840	.....	4.0	.....	5,880	386	92	9,090	.....
.....	1,620	680	.....	27	.....	3,550	2,580	14	4,620	.....
.....	2,660	382	.....	20	.....	4,580	2,490	31	5,310	.....
.....	1,270	820	.....	15	.....	3,280	1,250	59	4,970	7.5
.....	863	7,320	1.4	.....	2.1	13,700	880	92	22,200	7.7
.....	239	312	.....	14	.....	1,160	512	47	1,890	.....
12	208	1,140	.....	4.5	.....	2,380	202	90	4,350	.....
.....	1,620	460	.....	1.2	.....	3,580	574	79	5,220	.....
30	1,390	2,540	.....	.....	.....	6,510	585	89	9,970	.....
.....	2,410	4,300	.....	.....	.....	10,800	848	90	16,100	.....
.....	3,200	8,020	.....	.....	.....	17,700	3,100	79	25,500	.....
.....	295	60	1.4	.5	2.1	1,240	104	89	1,840	7.5
.....	1,850	10,800	.6	.....	2.1	20,600	1,210	93	31,400	7.4
formation										
.....	237	560	.....	0.0	.....	1,350	469	60	.....	.....
.....	870	41	.....	.....	.....	1,560	.....	.....	.....	.....
.....	877	43	3.2	.0	.....	1,520	1,020	19		
.....	1,310	27	.....	.25	.....	2,120	1,640	3	.....	.....
.....	598	1,290	.....	4.5	.....	3,420	304	89	5,650	7.9
.....	407	350	.....	3.0	.....	1,470	238	80	.....	.....
.....	951	1,010	.....	.5	.....	3,620	208	93	.....	.....
13	269	248	2.0	1.8	.....	1,200	48	95	.....	8.0

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Travis Peak
K-9.....	Falls.....	30	0.25	78	18	415	14	350
K-10.....	Tarrant.....	11	.....	18	2.4	459		688
K-11.....	Dallas.....	24	.01	8.0	2.8	381		528
K-12.....	Dallas.....	.....	.32	126	54	2,230		40
K-13.....	Dallas.....	26	.02	6.4	2.4	378		491
K-14.....	Dallas.....	25	.02	6.8	2.4	394		488
								Glen Rose
K-15.....	Medina.....	11	.....	486	347	4.4		230
K-16.....	Medina.....	9.5	.....	540	369	17		238
K-17.....	Medina.....	13	0.62	476	106	53		184
K-18.....	Medina.....	9.5	.19	540	434	61		251
K-19.....	Medina.....	13	.00	538	344	54		303
K-20.....	Medina.....	11	.....	186	141	52		350
K-21.....	Bexar.....	14	.00	484	247	43		273
K-22.....	Bexar.....	14	.....	324	267	12		277
K-23.....	Comal.....	.....	.....	326	220	17		360
K-24.....	Comal.....	.....	.....	.....	.....	.....		245
K-25.....	Hays.....	11	.....	274	108	54		380
K-26.....	Travis.....	10	.....	258	214	65		400
K-27.....	Bell.....	12	.....	39	41	417		409
K-28.....	Bell.....	.....	.....	.....	.....	.....		438
K-29.....	Falls.....	.....	9.2	266	62	2,250		300
K-30.....	Grayson.....	8.0	.04	128	71	334		193
								Paluxy
K-31.....	Bosque.....	15	.....	27	20	1,110		598
K-32.....	Hill.....	6.0	0.12	11	8.4	629	16	561
K-33.....	Hill.....	10	.12	5.2	1.8	492	19	420
K-34.....	Dallas.....	22	.12	10	3.8	851	4.4	529
K-35.....	Dallas.....	32	.21	4.2	2.0	544		605
K-36.....	Dallas.....	20	.07	5.6	1.8	506		597
K-37.....	Parker.....	20	.....	225	205	167		533
K-38.....	Parker.....	22	.....	188	39	168		514
								Trinity
K-39.....	Pecos.....	.....	.....	.....	.....	.....		284
K-40.....	Pecos.....	.....	.....	.....	.....	.....		150
K-41.....	Upton.....	18	.....	280	161	248		187
K-42.....	Upton.....	18	0.15	150	78	142	5.2	336
K-43.....	Upton.....	8.2	.10	150	117	276	7.6	312
K-44.....	Reagan.....	10	.11	149	93	547	21	252
K-45.....	Reagan.....	8.0	3.9	156	103	285	19	262
K-46.....	Reagan.....	11	.28	136	84	238	16	246
K-47.....	Reagan.....	6.0	6.9	167	108	306	28	274
K-48.....	Medina.....	20	.48	137	67	533		376
K-49.....	Bexar.....	28	.07	186	56	619	35	320
K-50.....	Kendall.....	.....	.....	205	120		9	342
K-51.....	Hays.....	13	.....	198	150	89		343
K-52.....	Travis.....	15	.38	91	26	513	29	396
K-53.....	Travis.....	18	.08	42	22	294	11	270
K-54.....	Williamson.....	13	.08	17	15	632		432
K-55.....	Williamson.....	20	.10	17	6.1	462		452
K-56.....	Bell.....	10	.86	60	42	712	13	410
K-57.....	Bell.....	12	.06	13	7.6	519		490

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
formation—Continued										
.....	749	83	2.3	0.0	.....	1,560	268	76	2,260	8.1
30	106	250	.....	2.5	.....	1,200	55	95	2,050	8.6
28	253	94	2.6	.5	.....	1,030	32	96	.....	8.5
12	4,740	293	.....	.5	.....	7,470	536	90	.....	8.5
31	279	88	2.2	.0	.....	1,040	26	97	.....	8.5
10	341	80	1.7	2.5	.....	1,090	27	97	1,690	.....
limestone										
.....	2,320	23	4.0	3.0	0.65	3,310	2,640	4	3,530	7.9
.....	2,580	16	.....	.0	.....	3,650	2,860	1	3,690	7.0
.....	1,500	18	.....	.0	.....	2,260	1,620	7	2,490	7.8
.....	2,900	27	.....	4.0	.....	4,100	3,130	4	4,080	6.7
.....	2,480	30	.....	1.2	.....	3,610	2,760	4	3,640	7.3
.....	783	37	.5	.5	.....	1,380	1,040	10	1,790	7.3
.....	1,980	14	4.0	2.0	.....	2,920	2,220	4	3,090	7.2
.....	1,610	21	.....	.0	.....	2,380	1,910	1	3,830	8.0
.....	1,380	17	.....	.0	.....	2,370	1,720	2	.....	.....
.....	2,200	10	.....	.2	.....	>1,000	.....	.....	.....	.....
.....	802	70	.....	.5	.....	1,510	1,130	9	1,830	7.1
.....	1,240	33	.....	.0	1.1	2,020	1,520	9	2,450	7.7
.....	527	205	.....	.2	.....	1,440	266	77	2,250	8.4
20	250	246	.....	.....	.....	>1,000	.....	.....	.....	.....
.....	4,470	645	.....	.0	.....	8,020	919	84	.....	.....
.....	1,050	60	.4	.2	.....	1,750	612	54	2,360	7.5
sand										
.....	1,760	158	3.2	0.8	.....	3,390	150	94	4,690	8.3
.....	796	105	4.7	1.2	.....	1,850	62	94	.....	8.0
22	480	173	2.9	1.0	.....	1,400	20	96	.....	8.2
20	1,190	137	3.6	4.7	2.0	2,500	40	98	3,670	8.7
46	510	91	3.2	.2	.....	1,510	18	98	.....	8.4
32	466	80	3.2	.0	.....	1,390	22	98	.....	8.2
.....	167	815	.....	9.0	.....	1,870	1,400	21	3,110	7.8
.....	354	132	.3	22	.29	1,180	630	37	1,700	7.6
group										
.....	584	480	.....	.....	.....	>1,000	774	.....	2,820	7.7
.....	459	1,460	.....	.....	.....	>1,000	1,680	.....	6,990	7.6
.....	1,370	202	.....	44	.....	2,420	1,360	28	3,120	7.5
.....	545	108	2.0	12	0.71	1,230	695	31	1,770	7.2
.....	919	165	3.0	15	1.6	1,820	856	41	2,430	7.2
.....	704	760	2.6	15	.....	2,450	754	62	3,770	7.7
.....	985	144	2.6	9.0	.....	1,840	813	43	2,470	7.7
.....	813	112	2.6	11	.....	1,540	685	42	2,100	7.7
.....	947	244	2.6	.8	.....	1,940	861	43	2,680	7.4
.....	919	358	2.8	.2	.....	2,220	618	65	3,260	7.4
.....	956	580	2.4	.2	1.7	2,620	694	65	3,960	6.9
.....	688	13	3.1	.....	.....	1,210	1,000	1	.....	.....
8	896	54	2.2	2.0	.....	1,580	1,110	15	2,070	8.3
.....	739	270	4.0	2.2	.....	1,910	334	75	2,840	7.5
.....	523	62	1.0	.2	3.2	1,110	196	75	1,690	7.7
20	542	360	7.2	.0	.....	1,810	104	93	.....	8.5
.....	421	182	2.7	.0	.....	1,330	68	94	.....	7.8
.....	978	362	5.4	9.4	.....	2,400	322	82	.....	7.8
.....	376	275	4.0	.0	.....	1,450	64	95	.....	7.9

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Trinity
K-58	Bell	.....	.....	63	81	454		408
K-59	Coryell	14	0.43	27	7.6	750	56	380
K-60	Coryell	3.0	.09	8.4	4.6	437	23	442
K-61	Coryell	65	.52	16	10	412	12	352
K-62	Coryell	11	.03	34	57	898		595
K-63	Coryell	.....	.....	42	45	613		458
K-64	Falls	25	.14	55	17	491	12	433
K-65	McLennan	.....	.....	39	45	1,360		688
K-66	McLennan	20	.83	112	46	933		298
K-67	Hill	8.5	.10	22	28	668	22	488
K-68	Hill	18	.18	147	49	855	20	225
K-69	Hill	14	.08	46	22	401	12	345
K-70	Ellis	14	.04	13	5.2	358	7.8	483
K-71	Ellis	21	.07	5.4	2.1	429	7.2	512
K-72	Parker	20	.....	224	131	194		500
K-73	Tarrant	11	.....	6.2	1.6	413		742
K-74	Collin	20	.06	15	5.6	440	3.6	400
								Edwards limestone and
K-75	Kinney	.....	5.2	111	63	169		400
K-76	Kinney	.....	.....	60	74	216		524
K-77	Uvalde	15	.....	70	1.7	491		(a)
K-78	Medina	12	.....	176	107	9.0	.....	273
K-79	Bexar	14	.....	652	259	532		313
K-80	Bexar	.....	.....	231	82	59		380
K-81	Guadalupe	.....	.....	.....	.....	.....		196
K-82	Comal	7.2	.25	62	32	301		294
K-83	Hays	12	.....	82	57	207		301
K-84	Hays	10	.....	469	221	2,570		256
K-85	Travis	12	.....	272	206	1,310		288
K-86	Travis	12	.....	515	316	2,680		189
K-87	Travis	8.0	.00	140	94	115		292
K-88	Williamson	18	.14	17	12	534	.....	495
K-89	Milam	.....	.....	298	79	4,730		207
K-90	Lynn	25	.10	96	142	262	106	518
K-91	Jeff Davis	19	.04	191	86	473		285
K-92	Reeves	19	.04	190	80	448		286
K-93	Reeves	.....	.....	189	80	437		284
								Woodbine
K-94	McLennan	.....	.....	.....	.....	.....		396
K-95	McLennan	12	.....	148	39	1,040		180
K-96	Hill	7.0	0.04	5.7	2.4	812	10	750
K-97	Hill	7.0	.06	4.5	2.4	705	11	812
K-98	Hill	12	.05	3.2	1.5	583	7.6	644
K-99	Hill	9.8	.....	4.4	2.2	660		583
K-100	Navarro	.....	.12	13	5.4	1,810		1,580
K-101	Navarro	15	.32	9.4	3.0	1,040	11	1,110
K-102	Navarro	14	.03	3.5	1.1	594	10	779
K-103	Navarro	14	.05	6.2	2.4	981	9.2	1,077
K-104	Ellis	11	.08	3.1	1.7	519	6.6	732
K-105	Ellis	11	.10	5.0	1.9	645	8.0	730
K-106	Ellis	11	.31	4.6	2.1	807	9.0	1,005
K-107	Ellis	10	.06	4.5	2.1	785		974
K-108	Tarrant	24	.00	726	115	214		418
K-109	Dallas	20	.04	4.1	1.6	394		564
K-110	Dallas	13	.14	5.0	2.5	613	8.4	698

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
group—Continued										
.....	840	190	.....	1.5	.....	1,830	490	67	.....	.....
.....	700	530	4.4	1.8	.....	2,280	98	91	3,760	7.8
.....	233	286	4.0	2.2	.....	1,220	40	93	2,120	7.6
.....	334	246	1.8	5.0	.....	1,280	81	90	2,020	7.9
.....	1,470	180	.....	.2	.....	2,940	320	86	4,150	7.8
.....	798	295	.....	.0	.....	2,020	290	82	.....	.....
.....	802	66	3.1	.0	.....	1,680	208	83	2,440	7.8
.....	2,330	180	.....	.....	.....	4,300	282	91	.....	.....
.....	1,830	242	2.1	1.5	.....	3,330	468	81	.....	7.6
.....	1,090	73	5.0	.2	.....	2,160	170	88	.....	7.8
.....	2,070	76	1.4	1.0	.....	3,350	568	76	.....	7.8
41	683	40	2.3	4.0	.....	1,400	206	80	.....	8.2
42	245	110	1.2	.0	.....	1,010	54	92	.....	8.4
18	112	288	1.7	3.0	.....	1,130	22	97	.....	8.4
.....	88	720	.0	3.0	.....	1,630	1,100	28	2,920	7.8
38	91	129	.....	3.5	.....	1,040	22	98	1,740	8.7
.....	371	205	.9	2.0	0.76	1,260	60	94	2,070	8.0
associated limestones										
.....	258	212	3.0	0.6	.....	1,010	536	41	.....	.....
.....	234	178	.....	.5	.....	1,020	453	51	.....	.....
53	784	225	1.0	11	.....	1,660	182	85	2,540	9.2
.....	625	11	.....	.8	.....	1,070	879	2	1,410	7.4
.....	2,040	1,040	.....	2.5	.....	4,690	2,690	30	6,060	8.0
.....	665	27	.....	.....	.....	1,250	914	12	.....	.....
.....	1,200	1,000	.....	.....	.....	>1,000	.....	.....	5,060	.....
.....	349	233	2.6	.0	.....	1,130	286	70	.....	.....
.....	324	208	3.2	3.0	.....	1,040	439	51	1,740	7.5
.....	2,720	3,280	2.8	.....	.....	9,400	2,080	73	13,400	7.2
.....	2,010	1,450	.....	1.0	.....	5,400	1,530	65	7,840	7.6
.....	2,750	3,830	.....	.....	.....	10,200	2,580	69	14,800	6.9
.....	93	458	.....	2.8	.....	1,050	736	25	1,990	7.4
.....	384	308	4.4	.5	.....	1,520	92	93	2,460	7.7
.....	6,300	3,270	.....	.....	.....	14,800	1,070	91	.....	.....
.....	685	222	18	39	.....	1,890	824	37	2,680	7.7
.....	691	655	.....	.6	.....	2,310	830	56	.....	.....
.....	651	610	.....	.9	.....	2,200	803	55	.....	.....
.....	635	608	.....	.....	.....	2,100	800	54	.....	.....
sand										
.....	1,770	760	.....	.....	.....	4,100	305	91	5,930	8.1
.....	2,270	198	.....	0.0	1.1	3,800	530	81	5,030	.....
.....	505	460	4.4	2.0	.....	2,180	24	98	.....	8.0
52	538	199	4.4	4.5	.....	1,900	21	98	.....	8.2
10	487	166	4.4	1.8	1.5	1,590	14	98	2,440	8.2
.....	681	182	3.4	2.2	.....	1,830	20	99	2,760	8.3
.....	153	1,790	2.5	.....	.....	4,550	55	99	.....	.....
10	491	612	2.3	3.2	.....	2,740	36	98	4,450	7.5
43	441	131	2.1	4.4	.....	1,600	13	98	2,510	7.8
33	172	760	2.4	7.1	.....	2,550	26	98	4,220	7.7
18	337	126	3.0	.0	.....	1,380	14	98	.....	8.4
24	501	195	5.0	8.2	.....	1,750	20	98	.....	8.4
25	500	285	6.0	.8	.....	2,140	20	98	.....	8.4
16	488	277	5.6	.5	.....	2,060	20	99	.....	8.2
.....	1,960	258	.....	4.5	.....	3,510	2,280	17	3,960	6.9
.....	307	63	1.4	.0	.....	1,060	16	98	.....	.....
.....	498	185	4.0	4.6	3.0	1,680	23	98	3,020	8.0

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Woodbine
K-111	Kaufman	15	0.06	8.5	3.1	1,360	4.0	1,184
K-112	Kaufman	6.0	.02	6.7	2.1	985	3.8	1,076
K-113	Rockwall	.....	.....	10	4.4	1,530		1,080
K-114	Collin	13	.02	6.0	2.1	758	5.4	803
K-115	Collin	14	.91	14	8.0	1,370	20	701
K-116	Collin	11	.36	8.4	4.5	1,120	6.2	758
K-117	Collin	12	.05	10	4.4	1,030	10	780
K-118	Grayson	17	.14	13	6.6	1,170	13	591
								Blossom
K-119	Red River	15	0.04	5.3	1.0	384	4.8	407
								Nacatoch
K-120	Hunt	16	0.04	4.6	1.4	692		886
K-121	Hunt	10	.06	9.2	2.1	355	12	437
K-122	Hunt	10	.04	40	8.3	405	14	330
K-123	Hopkins	10	.....	4.8	1.7	405		513
K-124	Bowie	.....	.....	2.8	1.2	525		700
K-125	Red River	15	.05	2.8	1.0	413		544
								Wilcox
E-1	Webb	.....	.....	.....	.....	.....		1,600
E-2	Caldwell	15	0.12	2.2	1.3	525	22	735
E-3	Caldwell	8.0	.09	2.0	1.4	416	5.2	502
E-4	Bastrop	55	.01	382	83	129		276
E-5	Bastrop	20	.07	25	9.1	508	....	659
E-6	Bastrop	.....	.....	436	144	165		.....
E-7	Bastrop	55	.....	1,220	423	488		54
E-8	Bastrop	28	.....	139	50	198		132
E-9	Brazos	.....	.....	4	.....	459		1,130
E-10	Cherokee	16	.2	1.8	.7	409		892
E-11	Gregg	.....	.....	15	6	577		281
E-12	Gregg	.....	.....	.....	.....	.....		598
E-13	Gregg	.....	.....	.....	.....	.....		586
E-14	Gregg	.....	.....	4.4	3.9	636		604
E-15	Harrison	.....	.....	60	11	319		317
E-16	Morris	.....	.....	134	50	129		12
								Indio
E-17	Dimmit	33	0.10	116	25	291	9.5	502
E-18	Dimmit	19	.....	52	34	624		414
E-19	Dimmit	18	.....	158	61	964		330
E-20	Zavala	36	.....	387	89	604		298
E-21	Medina	16	.....	196	80	520		471
E-22	Medina	66	.....	213	24	196		410
E-23	Medina	14	.....	48	31	991		586
E-24	Medina	42	.....	236	11	138		340
E-25	Medina	16	.....	52	39	1,020		834

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
sand—Continued										
26	269	1,210	3.7	2.2	.....	3,470	34	99	5,970	8.2
24	453	548	4.0	14	.....	2,570	25	99	4,210	8.2
.....	43	1,730	.....	.....	.....	3,840	43	98	.....	.....
40	425	378	3.2	5.7	.....	2,010	24	98	.....	8.2
.....	800	1,180	1.6	.5	.....	3,750	68	97	.....	8.2
68	13	1,270	2.2	10	.....	2,850	40	98	.....	8.4
51	654	660	2.7	.5	.....	2,800	43	98	.....	8.3
.....	1,400	472	2.6	.8	.....	3,380	60	97	.....	8.4
sand										
30	201	204	0.4	2.0	.....	1,030	17	97	1,790	8.4
sand										
.....	2	554	4.8	0.0	.....	1,710	18	99	.....	8.1
.....	354	62	.1	6.2	.....	1,030	32	94	1,750	7.6
.....	645	65	.0	.0	.....	1,350	134	85	2,170	7.4
.....	94	265	1.8	5.0	.....	1,040	19	98	1,790	8.0
.....	4	408	.....	1.0	.....	1,290	12	99	.....	.....
.....	2	326	.3	.2	.....	1,030	11	99	.....	.....
group										
.....	3.9	1,650	.....	.....	.....	>1,000	37	.....	6,940	8.1
51	212	222	0.4	1.2	.....	1,390	11	97	2,310	8.3
43	227	170	.0	.0	.....	1,100	11	98	.....	8.4
.....	928	272	.....	.5	.....	1,990	1,290	18	2,590	7.4
29	3.6	450	.....	.....	.....	1,350	101	92	.....	8.1
.....	1,640	235	.....	1.2	.....	2,620	1,680	18	.....	.....
.....	967	3,400	.....	.....	.....	6,580	4,780	18	10,900	7.0
.....	46	580	.....	11	.....	1,120	552	44	2,140	7.2
.....	11	50	2.2	.....	.....	1,080	10	.....	.....	.....
58	.0	88	.....	.....	.....	1,470	7.4	99	.....	.....
.....	33	750	.....	.....	.....	1,520	64	95	.....	.....
.....	27	740	.7	.....	.....	1,780	17	.....	.....	.....
.....	23	780	.6	.....	.....	1,830	23	.....	.....	.....
.....	23	630	.5	.....	.....	1,600	27	98	.....	.....
.....	192	305	.1	.....	.....	1,040	197	78	.....	.....
.....	584	143	.3	.0	.....	1,050	541	34	.....	.....
formation										
.....	385	169	.....	0.12	.....	1,280	392	82	.....	.....
.....	126	820	.....	.0	.....	1,880	270	83	3,530	7.8
.....	1,750	460	.....	.8	.....	3,570	646	76	5,030	7.8
.....	842	1,080	.....	.0	.....	3,180	1,330	50	4,860	7.8
.....	733	565	.....	4.8	.....	2,350	818	58	3,610	7.2
.....	229	322	.....	34	.....	1,290	630	40	2,080	8.1
.....	393	1,070	.....	4.0	.....	2,840	248	90	4,830	7.8
.....	81	312	.....	164	.....	1,150	634	32	1,910	7.0
.....	15	1,290	.....	.0	.....	2,840	290	88	5,080	7.6

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Carrizo
E-26	Webb	.....	.....	.....	.....	.....		1,559
E-27	Dimmit	26	0.26	350	207	1,610	23	321
E-28	Dimmit	14	.15	68	34	2,630	26	333
E-29	Dimmit	.....	.....	46	34	714		326
E-30	Dimmit	18	.30	16	6.9	392	25	240
E-31	La Salle	26	.06	2.1	1.0	443		741
E-32	McMullen	36	.06	.6	1.1	591		1,280
E-33	Atascosa	30	.19	3.6	.7	244	2.0	504
E-34	Atascosa	14	.02	3.1	.8	820		1,402
E-35	Atascosa	.....	.....	297	99	270		170
E-36	La Salle	.....	.5	14	4.0	396	.....	714
E-37	Bexar	.....	37	.....	.....	.....		318
E-38	Wilson	31	.3	112	32	151	34	0
E-39	Caldwell	.....	.....	.....	.....	.....		.....
E-40	Bastrop	10	.21	220	99	1,060		82
E-41	Bastrop	10	.....	232	94	189		270
E-42	Lee	12	.01	5.1	2.1	417	9.4	762
E-43	Angelina	.....	.....	14	7.4	.....		1,024
E-44	Angelina	.....	.....	11	4.8	.....		432
								Bigford member of the
E-45	Dimmit	.....	.....	32	15	1,830		384
E-46	Dimmit	12	1.1	385	218	3,390	50	278
								Queen City sand member of
E-47	Webb	.....	.....	.....	.....	....		822
E-48	Atascosa	10	.....	67	37	931		420
E-49	Wilson	16	.....	143	58	122	....	194
E-50	Bastrop	106	48	61	27	164	21	.....
E-51	Burleson	.....	.05	3.4	1.2	649		1,445
E-52	Brazos	.....	.02	7.0	3.1	669		917
E-53	Angelina	.....	.....	10	.....	....		780
								Mount Selman
E-54	La Salle	37	0.63	3.1	0.7	933	13	1,489
E-55	Frio	52	.08	176	22	138	12	304
E-56	Atascosa	15	.....	338	121	1,760		214
E-57	Atascosa	14	.....	30	15	932		366
E-58	Atascosa	14	.08	4.8	1.4	667	4.6	743
E-59	Atascosa	12	.04	6.3	1.8	1,220	15	1,600
E-60	Bastrop	.....	90	271	3.0	226		70
								Sparta
E-61	Lee	34	.....	248	92	350		337
E-62	Burleson	16	0.22	129	70	59	....	376
E-63	Burleson	.....	.02	19	2.3	635		644
E-64	Angelina	.....	.....	10	2.3	717		226
E-65	Sabine	16	.09	2.0	1.0	514		1,040

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
sand										
31	7.8	1,260	.....	.....	.....	>1,000	18	.....	5,900	8.3
.....	1,610	2,350	.....	3.0	.....	6,400	1,720	67	.....	.....
.....	956	3,460	.....	2.3	.....	7,430	309	95	.....	.....
.....	402	795	.....	.8	.....	2,150	255	86	3,730	.....
.....	212	378	1.0	1.2	.....	1,170	68	89	.....	7.9
.....	104	179	.9	.0	.....	1,120	9	99	.....	8.4
.....	2.6	168	.4	.0	.....	1,430	6	100	.....	8.2
.....	65	44	.6	.0	.....	675	12	97	1,010	8.1
48	129	322	3.4	1.8	.....	2,010	11	99	3,440	8.3
.....	760	570	.....	.....	.....	2,190	1,150	34	.....	.....
56	110	118	.....	.....	.....	1,150	51	.....	.....	.....
.....	.....	585	.....	.....	.....	>1,000	1,730	.....	3,390	7.3
.....	604	180	.....	.15	.....	1,130	411	24	.....	.....
.....	1,100	700	.....	.....	.....	>1,000	.....	.....	.....	.....
.....	762	1,700	.....	.5	.....	3,890	956	71	6,380	7.1
.....	858	185	.0	1.5	.....	1,700	966	30	2,310	7.8
17	155	94	1.9	.8	.....	1,080	21	96	1,720	8.5
66	4	858	.....	.....	.....	2,320	65	97	.....	.....
.....	360	140	.....	.....	.....	1,090	47	95	.....	.....
Mount Selman formation										
.....	680	2,190	.....	.....	.....	4,930	142	97	.....	.....
.....	4,070	3,420	.....	2.1	.....	11,800	1,860	80	.....	.....
the Mount Selman formation										
22	418	1,330	.....	.....	.....	>1,000	20	.....	5,890	8.4
.....	1,330	435	.....	1.8	2.4	2,980	319	86	4,360	.....
.....	400	202	.....	1.0	.64	1,040	596	31	1,640	8.0
.....	1,080	370	0.5	5.0	.72	2,050	402	22	2,480	3.7
35	1	144	2.5	.0	.....	1,530	13	99	.....	.....
22	4.1	502	1.1	.0	.....	1,650	30	98	.....	.....
.....	1	1,400	.....	.....	.....	>1,000	33	.....	.....	.....
formation										
41	192	422	4.4	1.0	.....	2,360	10	99	3,660	8.0
.....	177	282	.....	9	.....	1,020	530	36	.....	.....
.....	2,450	1,730	.....	2.0	5.3	6,530	1,340	74	9,160	.....
.....	894	660	.....	1.8	2.8	2,690	136	94	4,270	.....
29	152	497	1.7	2.0	.....	1,710	18	98	3,070	8.2
67	169	850	1.2	1.0	.....	3,060	23	98	5,190	8.1
.....	621	337	.....	.....	.....	1,890	490	42	.....	.....
sand										
.....	557	640	.....	0.2	0.70	2,090	998	43	3,390	7.4
.....	244	151	0.0	.2	.....	1,030	610	17	1,420	7.5
8	98	570	1.4	.0	.....	1,720	57	96	.....	8.7
.....	91	920	.....	19	.....	>1,000	34	98	.....	.....
28	3	191	.....	.5	.....	1,240	9	99	.....	.....

Table 1.— *Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Upper part of
E-66	Webb	.....	0.16	6.5	3.8	1,350		598
E-67	La Salle	11	.....	35	11	2,060		439
E-68	La Salle	21	1.8	106	45	430	....	299
E-69	Wilson	.....	1.8	8.0	2.0	452		644
E-70	McMullen	122	10	486	211	2,620	123	.....
E-71	Burleson	.....	.31	69	3.5	587		492
E-72	Burleson	.....	.14	62	11	457		370
E-73	Angelina	.....	4.9	.....	.....	....		568
E-74	Angelina	.....	20	72	20	473		412
E-75	Jasper	.....	.....	140	24	2,060		531
E-76	Jasper	.....	.....	675	66	4,880		217
E-77	Jasper	.....	.....	3.4	2.4	416		183
								Jackson
E-78	Starr	24	.....	702	48	1,990		30
E-79	Starr	18	.....	9.5	6.6	1,840		1,614
E-80	Starr	5.6	.....	598	165	9,290		93
E-81	Live Oak	.....	.....	41	5.6	1,200		386
E-82	Walker	46	.....	77	7.1	327		164
E-83	Walker	42	.....	17	1.8	470		522
E-84	Angelina	.....	1.8	49	15	....		444
								Catahoula sandstone, Oakville sandstone,
M-1	Hidalgo	68	.....	74	36	993		154
M-2	Hidalgo	.....	.....	43	27	806		248
M-3	Starr	34	.....	491	28	6,160		115
M-4	Starr	24	.....	132	27	1,350		167
M-5	Jim Hogg	38	0.17	18	3.7	342	12	198
M-6	Duval	11	.05	52	12	1,650	32	326
M-7	Duval	56	.10	88	24	921	29	353
M-8	Duval	18	.08	52	12	1,660	32	322
M-9	Duval	.....	.....	.....	.....	358		243
M-10	Live Oak	30	.56	74	20	300	55	343
M-11	Bee	19	.15	7.1	1.3	514	27	601
M-12	Bee	33	1.9	182	31	166	23	344
M-13	Karnes	46	.18	68	9.4	341	31	428
M-14	Karnes	72	.03	6.7	.6	433	21	313
M-15	De Witt	25	.26	8.8	1.4	408	17	565
M-16	Lavaca	40	.....	384	49	248		450
M-17	Walker	72	.....	268	32	376		66
M-18	Polk	.....	2.7	33	2.7	406		356
M-19	Polk	.....	.50	141	13	656		542
								Ogallala
O-1	Midland	58	.....	150	48	164		214
O-2	Midland	.....	.....	100	66	399		218
O-3	Midland	60	0.10	127	79	153	12	235
O-4	Andrews	.....	.....	164	53	455		192
O-5	Martin	77	.....	104	67	237	12	232
O-6	Howard	63	.08	249	94	177	20	260
O-7	Dawson	67	.....	142	116	176		316
O-8	Borden	46	.....	136	100	144		440
O-9	Borden	50	.....	129	57	161		265
O-10	Scurry	9.6	.....	7.0	6.3	600		526
O-11	Yoakum	42	.08	114	111	179	34	241

See footnotes at end of table.

measurements of saline ground water in Texas—Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
Claiborne group										
24	1,630	538	.....	1.0	.....	3,870	32	99	.....	.....
17	1,830	1,650	1.4	.5	.....	5,820	132	97	8,760	8.5
.....	589	385	.....	.0	2.0	1,720	450	68	2,700	7.7
34	163	202	.....	.....	.....	1,290	28	97	.....	.....
.....	8,680	1,020	.....	42	.....	>1,000	.....	54	13,400	3.3
.....	222	585	.5	3.6	.....	1,810	187	87	.....	7.9
.....	284	420	.6	.0	.....	1,470	200	83	.....	7.5
8	210	250	.....	.....	.....	1,170	18	.....	.....	.....
14	609	375	.....	.....	.....	1,870	262	83	.....	.....
.....	12	3,060	.....	.....	.....	5,450	448	91	.....	.....
.....	9.8	8,700	.....	.0	.....	15,100	1,960	84	.....	.....
.....	604	41	.....	.....	.....	1,330	18	98	.....	.....
group										
.....	2,600	2,520	.....	.....	5.1	7,900	1,950	69	10,800	6.5
126	78	1,800	.....	0.0	15	4,620	50	99	7,480	8.8
.....	2.6	15,800	.....	.....	13	25,900	2,170	90	38,400	7.1
.....	819	1,110	0.2	.....	.....	3,430	125	95	.....	.....
.....	293	348	.....	2.2	.....	1,180	221	76	1,850	.....
28	1.2	435	.....	7.5	.....	1,250	50	95	2,170	.....
.....	460	211	.....	.....	.....	1,460	184	84	.....	.....
and Lagarto clay, undifferentiated										
23	492	1,300	.....	1.5	5.8	3,050	332	87	5,130	.....
.....	409	950	.....	1.5	.....	2,360	218	89	4,040	.....
.....	1,190	9,500	.....	.....	13	17,500	1,340	91	26,300	7.4
.....	384	2,020	.....	.....	3.6	4,020	440	87	6,920	7.9
.....	131	361	0.4	12	.....	1,020	60	91	1,740	7.7
.....	6.8	2,510	.2	3.2	.....	4,440	180	94	8,370	7.4
.....	191	1,320	.4	7.0	.....	2,810	318	85	5,050	7.4
.....	7.8	2,520	.2	2.2	.....	4,460	180	94	8,320	7.5
.....	54	560	.....	29	.....	1,220	291	73	.....	.....
.....	316	267	1.4	.0	.....	1,230	266	66	1,930	7.4
.....	.9	480	1.8	.8	.....	1,350	23	95	2,310	7.5
.....	81	428	.6	1.2	.....	1,120	582	37	1,940	7.2
.....	112	365	1.0	5.0	.....	1,190	208	75	2,090	7.4
21	109	420	2.2	1.8	.....	1,230	19	95	2,170	8.2
.....	1.1	334	.4	.2	.....	1,070	28	95	1,890	7.8
.....	41	910	.....	5.5	.....	1,900	1,160	32	3,520	7.1
.....	996	372	.....	3.5	.....	2,150	800	51	2,990	.....
22	2	470	.....	1.0	.....	1,100	94	90	2,030	.....
18	2	970	.....	1.5	.....	2,060	406	78	3,680	.....
formation										
.....	220	365	.....	12	.....	1,120	572	38	1,900	7.8
.....	824	240	.....	17	.....	1,750	521	62	.....	.....
.....	378	273	2.7	16	.....	1,220	642	34	.....	7.2
16	587	375	.....	7.0	.....	1,740	628	61	2,460	.....
.....	322	378	2.8	6.0	0.81	1,320	535	48	2,130	8.2
.....	335	590	1.4	26	.....	1,680	1,010	27	2,790	7.2
.....	254	472	2.8	23	.....	1,410	832	32	2,350	8.2
.....	181	238	.....	222	.....	1,280	750	29	2,050	.....
.....	260	282	.....	28	.....	1,100	556	39	1,790	.....
28	305	407	.....	2.8	.....	1,610	44	97	2,770	.....
.....	779	102	5.5	8.0	.....	1,490	741	33	2,160	7.7

Table 1.—*Chemical analyses and related physical*

Well or spring no.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Ogallala
O-12.....	Gaines.....	.....	.....	164	193	420		336
O-13.....	Terry.....	.....	.....	75	95	186		288
O-14.....	Terry.....	.....	.....	70	101	198		270
O-15.....	Lynn.....	60	.....	98	104	222		314
O-16.....	Lynn.....	8	.....	69	52	1,590		314
O-17.....	Lynn.....	65	.....	118	142	288		178
O-18.....	Lynn.....	52	.....	194	165	595		272
O-19.....	Lynn.....	26	.....	727	1,520	3,090		276
O-20.....	Hockley.....	62	0.08	104	107	83	18	337
O-21.....	Lubbock.....	.....	.....	78	96	164		386
O-22.....	Lubbock.....	.....	.....	76	94	166		345
O-23.....	Lamb.....	60	.....	216	211	755		326
O-24.....	Lamb.....	60	.....	251	246	742		410
O-25.....	Lamb.....	70	.....	552	466	884		236
O-26.....	Donley.....	34	.....	446	64	42		43
O-27.....	Donley.....	44	.....	588	61	74		99
O-28.....	Oldham.....	17	.....	4	4	371		509
O-29.....	Gray.....	11	.08	72	31	278	12	228
								Goliad sand, Willis sand and
O-30.....	Cameron.....	44	.....	104	109	1,140	....	447
O-31.....	Cameron.....	32	.....	135	81	1,230	....	309
O-32.....	Cameron.....	32	.....	43	42	1,080	....	574
O-33.....	Willacy.....	.....	.....	106	28	1,070		103
O-34.....	Willacy.....	16	0.01	26	8.4	771	4.3	166
O-35.....	Hidalgo.....	32	.01	187	67	376	8.3	216
O-36.....	Hidalgo.....	18	.00	82	41	543	8.0	258
O-37.....	Hidalgo.....	20	.01	78	33	610	6.9	284
O-38.....	Hidalgo.....	29	.00	82	46	796	9.0	360
O-39.....	Hidalgo.....	24	.00	97	48	657	11	378
O-40.....	Starr.....	96	.....	292	49	2,080		236
O-41.....	Starr.....	26	.....	74	7.9	2,640		311
O-42.....	Jim Hogg.....	.....	.....	4	.....	585		428
O-43.....	Kenedy.....	.....	.....	17	7.5	467		156
O-44.....	Kleberg.....	16	.08	33	11	358		267
O-45.....	Webb.....	.....	.....	.....	.....	.....		167
O-46.....	Duval.....	25	.54	92	48	278	8.5	274
O-47.....	Duval.....	29	.02	41	17	364	12	297
O-48.....	Jim Wells.....	18	.03	30	17	317	10	358
O-49.....	Jim Wells.....	.....	.....	26	16	451		268
O-50.....	Jim Wells.....	20	3.2	70	27	297		389
O-51.....	Nueces.....	30	.....	33	12	461		395
O-52.....	San Patricio.....	13	.28	27	8.7	347	9.9	337
O-53.....	San Patricio.....	10	.11	13	2.5	804	14	363
O-54.....	San Patricio.....	8.0	.08	18	3.9	992	16	411
O-55.....	Live Oak.....	20	.....	21	9.1	484		292
O-56.....	Brazoria.....	.....	.....	.....	.....	920		376
O-57.....	Galveston.....	14	.....	26	13	750		307
O-58.....	Harris.....	18	.02	6.0	2.1	436	1.7	643
O-59.....	Harris.....	12	.58	15	6.4	931		706
O-60.....	Liberty.....	29	.....	85	15	332		264
O-61.....	Liberty.....	.....	.40	26	3.3	423		240
O-62.....	Jefferson.....	21	.46	64	30	1,660		286
O-63.....	Orange.....	24	.12	16	4.8	506		436
O-64.....	Hardin.....	16	.03	.....	.....	396		511

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
formation—Continued										
.....	931	615	.....	.....	.....	2,490	1,200	43	.....	.....
.....	373	254	0.0	.....	.....	1,120	578	41	.....	.....
17	301	320	.....	24	.....	1,160	590	42	.....	.....
.....	418	320	.....	13	.....	1,390	672	42	2,210	8.0
.....	667	2,050	.....	1.2	.....	4,590	386	90	7,780	7.8
.....	543	555	.....	15	1.3	1,820	878	42	3,040	7.9
.....	1,560	400	.....	56	.....	3,160	1,160	53	4,170	7.2
.....	5,970	5,920	.....	.....	.....	17,400	8,060	45	21,600	7.6
.....	360	166	2.8	12	.....	1,080	700	20	1,770	7.2
.....	398	151	.....	3.2	.....	1,080	589	38	.....	.....
.....	421	146	3.2	1.5	.....	1,080	576	38	.....	.....
.....	1,670	732	3.2	1.5	.....	3,810	1,410	54	5,260	8.0
.....	1,780	748	2.4	.5	.85	4,030	1,640	50	5,440	8.0
.....	3,020	1,310	4.4	23	3.4	6,450	3,290	37	8,030	7.5
.....	1,340	25	1.2	2.0	.....	1,980	1,380	6	2,180	7.8
.....	1,600	94	.....	1.5	.....	2,510	1,720	9	2,650	7.7
47	280	60	.....	3.2	.....	1,010	26	97	1,550	.....
.....	281	312	1.2	6.0	.....	1,120	307	65	1,890	7.8
Lissie formation, undifferentiated										
22	1,060	1,200	0.6	15	5.8	3,910	708	78	6,090	8.5
.....	975	1,450	.8	.5	5.4	4,060	670	80	6,380	7.4
.....	757	940	2.8	.2	2.4	3,180	280	89	5,050	7.6
13	1,580	685	.....	.4	.....	3,530	380	86	.....	.....
.....	830	570	2.4	.0	5.8	2,320	100	94	3,650	7.9
.....	570	565	.5	.2	.93	1,910	742	52	3,040	7.4
.....	579	542	.7	.2	3.2	1,940	373	76	3,160	7.8
.....	663	530	1.1	.2	4.4	2,090	330	80	3,310	8.1
.....	672	820	1.8	.2	4.4	2,640	394	81	4,250	7.7
.....	459	780	1.4	1.0	2.9	2,270	440	76	3,780	7.9
.....	1,640	2,520	.8	.....	6.7	6,810	930	83	10,100	7.9
.....	885	3,390	.....	.....	14	7,190	217	96	11,400	7.5
.....	314	420	5.0	.46	.....	1,480	12	.....	.....	.....
.....	513	302	.....	.5	.....	1,340	73	93	.....	.....
.....	270	278	.2	16	.....	1,110	128	86	.....	8.3
.....	.....	950	.....	.....	.....	>1,000	952	.....	4,200	7.8
.....	75	515	.....	7.5	.....	1,180	427	58	.....	.....
.....	231	338	.8	20	.....	1,200	172	81	2,060	7.8
.....	128	289	1.2	12	.....	1,020	145	81	.....	7.8
.....	180	495	.....	8.0	.....	1,320	131	88	.....	.....
.....	124	332	1.2	16	.....	1,080	286	69	1,850	7.6
.....	249	390	.....	2.2	2.4	1,370	132	88	2,300	7.6
14	43	378	1.0	2.8	.....	1,000	116	87	1,770	.....
11	.4	1,060	1.2	3.2	.....	2,090	61	97	3,830	.....
9	.2	1,340	1.4	.0	.....	2,590	82	96	4,740	.....
.....	2.3	638	.....	.5	.....	1,320	90	92	2,530	8.4
.....	2	1,350	.....	.....	.....	2,480	214	.....	.....	.....
.....	1	1,060	.6	1.0	.....	2,020	118	93	3,680	8.2
25	.7	305	4.8	.2	.25	1,100	24	97	1,950	8.6
43	.8	1,040	2.2	1.2	.....	2,380	64	97	5,540	.....
.....	3.5	550	.....	.0	.....	1,140	294	73	2,130	.....
.....	12	560	.....	.8	.....	1,140	78	92	.....	.....
.....	2	2,590	.2	.....	.....	4,510	283	93	.....	.....
.....	2	565	1.0	.0	.....	1,350	60	95	.....	.....
.....	5	330	3.6	.2	.....	1,180	37	96	1,790	7.8

Table 1.— *Chemical analyses and related physical*

Well or spring no	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
								Beaumont clay and
B-1	Cameron	36	.....	122	91	1,310		533
B-2	Kleberg	.....	.....	569	400	2,020		308
B-3	San Patricio	55	0.16	119	50	829	21	494
B-4	San Patricio	16	.05	21	8.4	531	7.7	380
B-5	San Patricio	16	.02	17	7.6	490	8.8	416
B-6	Aransas	15	.....	9.1	9.5	501		516
B-7	Calhoun	17	.08	45	35	837		506
B-7[b]	Calhoun	15	.06	.0	.0	53		26
B-8	Calhoun	.....	.....	180	70	514		276
B-9	Matagorda	12	.07	11	8.0	519		829
B-10	Matagorda	.....	.....	12	4.5	535		364
B-11	Brazoria	.....	.....	.....	.....	....		274
B-12	Brazoria	.....	.50	14	5.5	527		732
B-13	Galveston	34	.....	42	15	636	.....	347
B-14	Galveston	29	.....	46	16	578		340
B-15	Galveston	35	.....	87	53	2 130		330
B-16	Galveston	.....	.....	61	36	321	.....	616
B-17	Galveston	13	.....	47	48	837	.....	542
B-18	Chambers	20	.06	34	10	397		730
B-19	Chambers	16	.....	23	11	650		536
B-20	Chambers	17	.....	45	19	734		454
B-21	Chambers	16	.....	14	4.4	403		571
B-22	Jefferson	.....	.....	65	9.5	644		342
B-23[c]	Orange	.....	.....	22	9.2	692		267
B-23[c]	Orange	.....	.....	27	10	820		272
B-23[c]	Orange	.....	.....	66	27	1,310		300
				Alluvium				
R-1	El Paso	14	0.06	62	14	501	13	151
R-2[c]	El Paso	4.3	.03	81	26	256	12	77
R-2[c]	El Paso	14	.01	122	26	357	8.3	64
R-2[c]	El Paso	12	.02	370	62	1,940		54
R-2[c]	El Paso	6.8	.02	684	111	3,540		53
R-3	Hudspeth	20	.25	68	19	496	22	340
R-4	Culberson	20	.....	240	218	530		142
R-5	Culberson	20	.04	83	55	253	.....	274
R-6	Culberson	.....	.....	600	192		66	161
R-7	Reeves	32	.....	614	232	1,180		195
R-8	Reeves	43	.....	856	190	738		152
R-9	Ward	14		763	204	1,090	16	116
R-10	Ward	.....	.....	352	144	762		179
R-11	Loving	.....	.....	637	248	369		68
R-12	Mitchell	.....	.....	198	54	100		336
R-13	Jones	20	.00	38	36	351	2.3	444
R-14	Haskell	.....	.....	131	41	250		286
R-15	Haskell	21	.02	151	92	221	10	399
R-16	Knox	26	.02	113	60	294	10	394
R-17	Knox	21	.12	112	99	372	15	481
R-18	Knox	.....	.....	135	55	187		272
R-19	Baylor	15	.05	69	54	231		433
R-20	Wilbarger	.....	.....	90	105	526		566
R-21	Wilbarger	30	.....	332	73	666	.....	176
R-22	Cottle	20	.05	530	140	398	10	243
R-23	Childress	21	.05	184	39	164	6.2	173
R-24	Cameron	50	.....	110	45	178	.....	304
R-25	Cameron	44	.....	116	40	200	.....	292
R-26	Cameron	40	.....	350	156	731	.....	400
R-27	Hidalgo	24	.03	88	38	350	8.5	302
R-28	Hidalgo	30	.00	49	24	364	4.9	376

See footnotes at end of table.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
"Alta Loma" sand										
.....	1,240	1,280	.....	0.0	3.8	4,340	678	81	6,680	7.2
.....	627	4,640	.....	.....	.....	8,410	3,060	59	.....	.....
16	58	1,310	0.8	2.8	.....	2,700	530	77	4,720	7.7
14	113	570	1.8	2.8	.....	1,470	97	92	2,520	7.7
21	66	508	1.8	2.2	.....	1,330	85	93	2,310	7.8
.....	28	495	.....	.8	.....	1,310	62	95	2,360	8.2
.....	75	1,120	.7	2.0	.....	2,380	256	88	4,200	7.8
.....	1.1	65	.5	.0	.....	151	0	100	264	7.2
.....	19	1,140	.....	.5	.....	2,060	737	60	3,910	.....
.....	3	358	.6	.0	.....	1,320	60	95	.....	.....
26	2	630	.....	.8	.....	1,380	48	96	2,540	.....
.....	2	1,620	.....	.....	.....	2,820	.....	.....	.....	.....
.....	25	410	.....	.0	.....	1,340	58	95	.....	.....
.....	2.9	875	.4	1.0	.....	1,780	166	89	3,330	8.0
.....	2	820	.4	.2	.....	1,660	181	87	2,960	7.9
.....	.0	3,400	.....	.....	.....	5,870	435	91	10,500	7.5
.....	.....	351	.....	.....	.....	1,070	303	70	.....	.....
.....	57	1,160	.....	1.0	.....	2,430	315	85	4,370	8.2
.....	.2	275	.5	.0	.....	1,100	126	87	.....	8.2
.....	.6	762	.....	.0	.....	1,730	102	93	3,170	.....
.....	3.5	1,000	.....	.8	.....	2,040	190	89	3,840	.....
.....	68	275	.....	1.8	.....	1,060	53	94	1,830	8.3
.....	2	935	.....	.....	.....	1,820	201	87	.....	.....
14	2	965	.....	2.8	.....	1,830	93	94	.....	.....
16	2	1,170	.....	2.5	.....	2,170	108	94	.....	.....
9	2	2,030	.....	2.2	.....	3,590	276	91	.....	.....
Alluvium										
.....	195	708	0.9	0.0	0.29	1,580	212	83	2,870	7.4
.....	316	355	.3	3.0	.25	1,090	309	63	1,900	6.9
.....	569	405	.3	.0	.32	1,530	412	65	2,460	7.1
.....	1,110	2,980	.3	.....	.....	6,500	1,180	78	10,500	7.3
.....	1,990	5,490	.3	.....	.....	11,800	2,160	78	18,200	7.1
.....	373	468	5.3	16	.....	1,660	248	80	.....	7.8
.....	1,280	810	.....	23	.60	3,190	1,500	44	4,410	7.5
.....	311	308	.....	4.5	.34	1,170	433	56	1,970	7.3
.....	2,080	90	.....	3.5	.....	3,440	.....	6	3,390	.....
.....	2,210	1,840	.....	6.5	.88	6,210	2,490	51	8,370	7.2
.....	1,910	1,510	.....	468	1.6	5,840	2,920	37	7,560	7.1
.....	2,250	1,920	.....	.4	.....	6,320	2,740	47	.....	.....
.....	823	1,500	.....	.5	.....	3,670	1,470	53	.....	.....
.....	2,030	880	.....	1.2	.....	4,200	2,610	25	5,430	.....
.....	543	65	.....	.5	.....	1,240	716	23	.....	.....
.....	235	240	.8	95	2.0	1,240	243	76	2,050	7.9
.....	286	320	.....	70	.....	1,240	496	52	.....	.....
.....	251	365	1.2	177	.....	1,490	756	38	2,290	7.6
16	386	296	1.5	26	.....	1,410	528	54	.....	7.9
.....	469	340	1.9	183	.....	1,850	686	53	2,660	7.6
24	315	251	.....	54	.....	1,140	563	42	.....	.....
.....	207	75	1.2	270	.....	1,140	394	56	1,790	8.0
.....	418	610	.....	50	.....	2,080	656	64	.....	.....
.....	45	1,680	.....	22	.....	2,940	1,130	56	5,530	7.5
.....	1,350	830	.2	1.8	.....	3,400	1,900	31	4,870	7.9
.....	409	292	.6	3.0	.....	1,200	620	36	1,890	7.3
.....	280	208	2.0	.5	.57	1,020	460	46	1,640	7.6
.....	267	250	2.0	2.0	.44	1,070	454	49	1,720	7.4
.....	757	1,420	.....	5.6	1.2	3,660	1,520	51	5,700	7.7
.....	332	385	.9	.2	1.5	1,380	376	66	2,300	7.5
.....	347	242	1.8	1.0	1.5	1,250	221	78	2,030	7.8

Table 1.—*Chemical analyses and related physical*

Well or spring no	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)
				Alluvium				
R-29.....	Hidalgo.....	20	0.04	32	13	367	5.2	372
R-30.....	Hidalgo.....	23	.02	106	4.5	656	9.0	264
R-31.....	Hidalgo.....	21	.04	88	44	756	11	286
R-32.....	Hidalgo.....	26	.02	117	47	319	8.8	259
R-33.....	Starr.....	10	.....	102	31	1,440		188

aIncludes 5 ppm hydroxide (OH).
bDemineralized.
cDrill-stem test.

measurements of saline ground water in Texas— Continued

Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
				Alluvium						
.....	296	238	1.5	0.0	3.3	1,160	134	85	1,930	7.8
.....	742	630	.9	1.0	3.2	2,350	450	76	3,710	7.5
.....	461	950	.9	3.0	3.7	2,480	400	80	4,160	7.5
.....	310	468	.6	.2	1.2	1,420	486	58	2,430	7.4
.....	1,420	1,330	.....	4.0	4.2	4,430	382	89	6,640	7.9

Table 2.—*Records of saline*

[Use of water: D, domestic; S, stock; Ind, industrial;

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
CO-1	Eden	Concho	4,150	$8\frac{5}{8}$, $5\frac{1}{2}$	Hickory sandstone member
CO-2	4 mi. SW from San Saba	San Saba	560	.....	Ellenburger group
CO-3	19 mi. NW from Ozona	Crockett	6,235	.....	do
CO-4	4 mi. SW from Stiles	Reagan	9,172	.....	do
CO-5	23 mi. SW from Odessa	Ector	10,725	.....	do
CO-6	28 mi. NW from Odessa	do	8,605	.....	do
CO-7	16 mi. SW from Andrews	Andrews	8,948	.....	do
CO-8	30 mi. SW from Andrews	do	10,014	.....	do
CO-9	28 mi. W from Andrews	do	10,531	.....	do
CO-10	12 mi. SE from Snyder	Scurry	1,610	.....	do
C-1	9 mi. N from Brady	McCulloch	2,150	.....	Pennsylvanian undifferentiated
C-2	20 mi. NE from Brady	do	1,500	.....	do
C-3	2 mi. SW from Bridgeport	Wise	58	.....	do
C-4	19 mi. NW from Weatherford	Parker	432	5	do
C-5	Mineral Wells	Palo Pinto	202	.....	do
C-6	12 mi. SW from Weatherford	Parker	103	4	do
C-7	12 mi. W from Weatherford	do	100	6	do
C-8	5 mi. N from Lampasas	Lampasas	1,091	.....	do
C-9	16 mi. SE from Archer City	Archer	300	.....	do
C-10	Nocona	Montague	795	$8\frac{1}{4}$	do
C-11	do	do	780	$8\frac{5}{8}$	do
C-12	$3\frac{1}{2}$ mi. NW from Brady	McCulloch	900	.....	do
C-13	$3\frac{1}{2}$ mi. NE from Cisco	Eastland	317	.....	do
C-14	$2\frac{1}{2}$ mi. NE from Marble Falls	Burnet	342	6	do
P-1	1 mi. E from Dell City	Hudspeth	187	18	Bone Spring limestone
P-2	2 mi. N from Dell City	do	250	20	do
P-3	1 mi. W from Dell City	do	187	16	do
P-4	2 mi. NW from Dell City	do	390	18	do
P-5	Near Rustler Spring	Culberson	2,400	.....	Delaware Mountain group
P-6	8 mi. SE from Pecos	Reeves	5,100	.....	do
P-7	26 mi. NW from Mentone	Loving	3,414	.....	do
P-8	2 mi. S from San Angelo	Tom Green	135	.....	Clear Fork group
P-9	15 mi. E from San Angelo	do	102.5	6	do
P-10	14 mi. NE from San Angelo	do	218	12	do
P-11	do	do	180	12	do
P-12	Miles	Runnels	120	8	do
P-13	Merkel	Taylor	100	.....	do
P-14	do	do	60	5	do
P-15	Anson	Jones	85	11	do
P-16	7 mi. SE from Stamford	do	70	6	do
P-17	9 mi. W from Stamford	do	50	6	do
P-18	2 mi. NW from Anson	do	80	6	do
P-19	5 mi. N from Anson	do	60	.....	do
P-20	do	do	65	.....	do

water wells and springs in Texas

Irr, irrigation; P, public supply; N, none]

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
380	Sept. 5, 1945	.....	130	P	Mar. 16, 1952	127	
.....	.....	.....	11	.....	May 19, 1952	.....	
.....	.....	.....	.....	.....	June 11, 1953	.....	Todd oilfield.
.....	.....	.....	.....	.....	Nov. 1, 1942	.....	
.....	.....	.....	.....	.....	Aug. 1953	.....	Yarbrough and Allen oilfield
.....	.....	.....	.....	.....	June 9, 1953	.....	Andector oilfield
.....	.....	.....	.....	.....	June 10, 1953	.....	Martin oilfield
.....	.....	.....	.....	.....	Aug. 1953	.....	Dollarhide oilfield
.....	.....	.....	.....	.....	June 10, 1953	.....	Nelson oilfield
.....	.....	.....	.....	.....	June 12, 1953	.....	Buffalo Creek oilfield
.....	.....	.....	.....	.....	July 26, 1951	.....	
.....	.....	.....	.....	.....	.....do.....	.....	
.....	.....	.....	.....	.....	Feb. 20, 1942	.....	
131.1	Jan. 24, 1950	.....	.....	S	Jan. 24, 1950	.....	
199	Mar. 1931	.....	$\frac{1}{10}$	P	Mar. 9, 1931	71	
17.8	Feb. 21, 1950	.....	.....	S	Feb. 21, 1950	.....	
40	1946	.....	.....	D	Jan. 27, 1950	.....	
.....	.....	.....	.....	.....	Aug. 9, 1943	.....	
.....	.....	.....	.....	.....	Feb. 1948	.....	
.....	.....	.....	10	Ind	Nov. 9, 1944	.....	
206.08	Nov. 8, 1944	.....	32	P	July 8, 1944	.....	
.....	.....	.....	.....	.....	.....	.....	
111	Sept. 1951	.....	20	S, Irr	Sept. 25, 1951	.....	
.....	.....	.....	.....	S	June 7, 1949	.....	
47.7	Feb. 3, 1949	.....	2,200	Irr	Aug. 5, 1948	.....	
87.9	.....do.....	.....	1,800	Irr	Aug. 6, 1948	.....	
128.0	Nov. 11, 1948	.....	.....	Irr	Aug. 9, 1949	.....	
118.5	Feb. 3, 1949	.....	.....	N	Mar. 11, 1948	.....	
.....	.....	400	.....	.....	.....	.....	
.....	.....	.....	.....	N	May 5, 1942	.....	
.....	.....	.....	.....	N	June 14, 1940	.....	
69.9	Oct. 11, 1948	.....	.....	S	Oct. 11, 1948	.....	
37.9	Nov. 3, 1948	.....	1.5	S	Jan. 20, 1949	.....	
98.3	Feb. 24, 1950	.....	642	Irr	Aug. 1, 1950	70	
67.1	Jan. 3, 1951	.....	963	Irr	Apr. 19, 1951	70	
30	.....	.....	.....	P	Apr. 18, 1946	.....	
.....	.....	.....	.....	P	.....do.....	.....	
.....	.....	.....	125	P	Apr. 19, 1946	.....	
.....	.....	.....	60	P	June 16, 1953	.....	
59	July 7, 1953	.....	.....	D	July 7, 1953	.....	
20	July 11, 1953	.....	.....	D, S	July 11, 1953	.....	
.....	.....	.....	35	Ind	July 30, 1953	69	
22	July 15, 1953	.....	.....	D, S	July 15, 1953	.....	
.....	.....	.....	.....	.....	.....	.....	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
P-21	9 mi. W from Stamford	Jones	50		Clear Fork group
P-22	1 mi. SW from Benjamin	Knox	19	24	do
P-23	2 mi. SW from Seymour	Baylor			do
P-24	Seymour	do	33		do
P-25	7 mi. SW from San Angelo	Tom Green	122		San Angelo sandstone
P-26	Robert Lee	Coke			do
P-27	7 mi. N from Bronte	do	60		do
P-28	Blackwell	Nolan	284		do
P-29	15 mi. NW from Anson	Jones	160		do
P-30	21 mi. SW from Anson	do	90	6	do
P-31	14 mi. W from Anson	do	190	6	do
P-32	9 mi. E from Aspermont	Stonewall	32	36	do
P-33	7 mi. E from Aspermont	do	165	5¼	do
P-34	4 mi. W from Crowell	Foard	34		do
P-35	8 mi. SW from Chillicothe	Hardeman	116	6	do
P-36	8 mi. SE from Quanah	do	125	6	do
P-37	12 mi. S from Quanah	do	Spring		do
P-38	13 mi. S from Quanah	do	Spring		do
P-39	19 mi. NW from Anson	Jones		6	Blaine gypsum
P-40	3 mi. SW from Roby	Fisher	100	4	do
P-41	11 mi. NW from Aspermont	Stonewall	165		do
P-42	Paducah	Cottle	127	7	do
P-43	6 mi. NW from Quanah	Hardeman	165	6	do
P-44	15 mi. NW from Quanah	do	230	6	do
P-45	9 mi. NW from Quanah	do	146		do
P-46	9 mi. W from Quanah	do	103		do
P-47	4 mi. S from Arlie	Childress	150	14	do
P-48	1 mi. SE from Arlie	do	176	16	do
P-49	5 mi. SW from Arlie	do	200+		do
P-50	3 mi. SW from Arlie	do	177	16	do
P-51	6 mi. S from Arlie	do	100	16	do
P-52	7 mi. E from Childress	do	270	16	do
P-53	13 mi. SW from Childress	do	278	16	do
P-54	11 mi. SE from Childress	do	168	16	do
P-55	12 mi. NE from Wellington	Collingsworth	Spring		do
P-56	9 mi. N from Wellington	do	Spring		do
P-57	12 mi. W from Orla	Culberson	Spring		Rustler limestone
P-58	14 mi. SE from Orla	do	Spring		do
P-59	6 mi. NW from Kent	do	451		do
P-60	7 mi. SE from Pecos	Reeves			do
P-61	9 mi. SW from Pecos	do	195		do
P-62	16 mi. E from Saragosa	do	1,525	12	do
P-63	do	do	1,405	12	do
P-64	10 mi. SE from Pecos	do			do
P-65	Monahans	Ward	965		do
P-66	Grandfalls	Crane	461	4	do
P-67	27 mi. NW from Ft. Stockton	Pecos	5,326	14	do
P-68	30 mi. NE from Ft. Stockton	do	430	7, 5 3/16, 4	do
P-69	26 mi. NE from Ft. Stockton	do	1,415	5	do
P-70	9 mi. SW from Ft. Stockton	do	1,373	8¼	do
P-71	do	do	1,550	10	do
P-72	15 mi. S from Gail	Borden	585	6	Quartermaster formation
P-73	15 mi. W from Roby	Fisher	100+	6	do
P-74	7 mi. N from Roby	do	87	4½	do
P-75	8 mi. NW from Swenson	Stonewall	Spring		do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (*feet*)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	.....	.....	.....	
.....	.....	.....	.....	.....	Oct. 11, 1945	.....	
21	Mar. 14, 1950	.....	.....	.....	Mar. 14, 1950	.....	
17	Oct. 1943	.....	.....	.....	Oct. 1943	.....	
71	Oct. 8, 1948	.....	.....	.....	Oct. 8, 1948	.....	
.....	.....	.....	.....	.....	Feb. 3, 1948	.....	James oilfield
.....	.....	.....	.....	.....	Mar. 24, 1948	.....	
173.0	Mar. 25, 1948	.....	.....	D	Mar. 25, 1948	.....	
.....	.....	.....	.....	.....	.....	.....	
17.68	July 30, 1953	.....	.....	D, S	July 30, 1953	.....	
21.34	.....do.....	.....	.....	D, S	.....do.....	.....	
.....	.....	.....	.....	S	Oct. 30, 1945	.....	
.....	.....	.....	.....	S	.....do.....	.....	
30	Feb. 7, 1941	.....	.....	N	Feb. 7, 1941	.....	
.....	.....	.....	.....	S	Jan. 9, 1936	.....	
.....	.....	.....	.....	S	.....do.....	.....	
.....	.....	.....	.....	D, S	Jan. 4, 1936	.....	
.....	.....	.....	.....	D, S	.....do.....	.....	
.....	.....	.....	.....	S	July 30, 1953	70.5	
.....	.....	.....	.....	S	Nov. 25, 1943	.....	
.....	.....	.....	.....	.....	Aug. 3, 1950	77	
32.33	Oct. 25, 1945	.....	150	P	Oct. 25, 1945	70	
100	Mar. 1936	.....	6	S	Mar. 5, 1936	.....	
.....	.....	.....	.....	S	Jan. 28, 1936	.....	
.....	.....	.....	.....	Irr	Aug. 10, 1953	.....	
.....	.....	.....	900	Irr	Mar. 24, 1953	.....	
27.15	Sept. 26, 1953	.....	1,400+	Irr	Sept. 26, 1953	.....	
.....	.....	.....	1,050	Irr	Sept. 30, 1953	66	
93.19	Sept. 26, 1953	.....	1,000	Irr	Sept. 1953	.....	
74.25	.....do.....	.....	1,300	Irr	Sept. 26, 1953	.....	
49.15	.....do.....	.....	1,800	Irr	.....do.....	.....	
75	Feb. 1953	.....	1,100	Irr	Sept. 24, 1953	65	
55.9	Sept. 25, 1953	.....	178	Irr	Sept. 25, 1953	.....	
77.99	Jan. 8, 1954	.....	400	Irr	.....do.....	66	
.....	.....	1,350	.....	D	Sept. 7, 1952	.....	
.....	.....	.....	.....	S, Irr	Aug. 25, 1953	.....	
.....	.....	.....	.....	.....	Apr. 19, 1940	.....	
.....	.....	.....	.....	.....	May 16, 1940	.....	
.....	.....	.....	.....	.....	May 30, 1949	.....	
.....	.....	.....	.....	.....	June 13, 1949	.....	
.....	.....	.....	.....	Irr	Sept. 15, 1941	.....	
.....	.....	.....	.....	Irr	Jan. 17, 1940	.....	
.....	.....	.....	.....	Irr	Aug. 21, 1940	.....	
.....	.....	.....	.....	Irr	Aug. 25, 1939	.....	
31.6	Mar. 1951	.....	600	Irr	Mar. 30, 1951	74	
+2.5	1941	.....	.....	Ind	Apr. 2, 1941	.....	
3.1	Nov. 27, 1946	1,933	.....	S	Sept. 6, 1940	.....	
.....	.....	.....	.....	Irr	Oct. 24, 1946	.....	
.....	.....	.....	.....	S	Sept. 28, 1940	.....	
.....	.....	.....	.....	Irr	Apr. 3, 1944	.....	
.....	.....	.....	.....	Irr	Apr. 11, 1946	.....	
231.7	June 10, 1948	.....	.....	S	June 17, 1948	.....	
.....	.....	.....	.....	D, S	Dec. 20, 1943	.....	
72.5	Dec. 16, 1943	.....	.....	S	Dec. 16, 1943	.....	
.....	.....	.....	.....	.....	Aug. 3, 1950	75	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
P-76	8 mi. NW from Swensen	Stonewall	Spring		Quartermaster formation
P-77	9 mi. SW from Dickens	Dickens	57	6	do
P-78	2 mi. S from Matador	Motley	80		do
P-79	2 mi. NW from Matador	do	200		do
P-80	2 mi. E from Matador	do	76		do
P-81	2 mi. E from Estelline	Hall	Spring		do
P-82	2 mi. W from Plaska	do	55		do
P-83	2 mi. E of Brice	do	70	16	do
Tr-1	24 mi. SW from Odessa	Ector	650		Dockum group
Tr-2	21 mi. SW from Odessa	do	640	6	do
Tr-3	17 mi. SW from Odessa	do	700	6	do
Tr-4	12 mi. NW from Colorado City	Mitchell	117		do
Tr-5	6 mi. SE from Colorado City	do	261	5	do
Tr-6	8 mi. NW from Colorado City	do	160		do
Tr-7	18 mi. NW from Colorado City	do	170		do
Tr-8	16 mi. NW from Colorado City	do	243		do
Tr-9	9 mi. SW from Ira	Scurry	142	6	do
Tr-10	1 mi. W from Ira	do	120	6	do
Tr-11	4 mi. SE from Ira	do	111		do
Tr-12	5 mi. NE from Tahoka	Lynn	200	6	do
Tr-13	12 mi. SW from Floydada	Floyd	825		do
Tr-14	19 mi. SW from Gail	Borden	63	6	do
Tr-15	13 mi. NE from Gail	do	62	6	do
Tr-16	Gail	do	63	36	do
Tr-17	16 mi. NW from Colorado City	Mitchell	320		do
Tr-18	7 mi. S from Gail	Borden	335	7	do
Tr-19	16 mi. SE from Gail	do	119		do
Tr-20	Tascosa	Oldham	250	8	do
Tr-21	2 mi. NW from Lubbock	Lubbock	999		do
K-1	21 mi. NW from New Braunfels	Comal	280	6	Travis Peak formation
K-2	12 mi. NW from New Braunfels	do	300	6	do
K-3	5 mi. SW from Austin	Travis	977	6	do
K-4	15 mi. NW from Austin	do	422	6	do
K-5	10 mi. N from Austin	do	968	5	do
K-6	4 mi. N from Lampasas	Lampasas	280		do
K-7	4 mi. NE from Killeen	Bell	913		do
K-8	Temple	do	2,000		do
K-9	Lott	Falls	3,305		do
K-10	18 mi. NW from Fort Worth	Tarrant	330		do
K-11	4 mi. SW from Dallas	Dallas	2,921	18, 8	do
K-12	7 mi. E from Dallas	do	3,368		do
K-13	Dallas	do	2,700	26, 10	do
K-14	do	do	2,634	18, $6\frac{5}{7}$	do
K-15	24 mi. NE from Hondo	Medina	671	7^{8}	Glen Rose limestone
K-16	18 mi. NE from Hondo	do	495	7	do
K-17	28 mi. NW from Hondo	do	220	6	do
K-18	17 mi. N from Hondo	do	585	8	do
K-19	20 mi. NW from Hondo	do	200	7	do
K-20	18 mi. NW from Hondo	do	460	6	do
K-21	10 mi. N from San Antonio	Bexar	462	4	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	.....	Aug. 3, 1950	75	
.....	.....	.....	.....	.....	Feb. 18, 1946	63	
.....	.....	.....	.....	.....	Nov. 7, 1939	.....	
.....	.....	.....	3	.....	Nov. 8, 1939	.....	
.....	.....	.....	2	.....	Nov. 7, 1939	.....	
.....	.....	600	.....	.....	May 1943	68	
21.95	Nov. 29, 1949	.....	150	Irr	Nov. 29, 1949	66	
.....	.....	.....	600	Irr	July 19, 1949	.....	
.....	.....	.....	.....	N	Sept. 29, 1948	.....	
.....	.....	.....	.....	S	Oct. 12, 1948	.....	
.....	.....	.....	.....	S	do	.....	
.....	.....	.....	.....	.....	May 18, 1948	.....	
.....	.....	.....	300	Irr	May 7, 1953	.....	
.....	.....	.....	.....	.....	May 20, 1948	.....	
.....	.....	.....	.....	.....	May 7, 1948	.....	
.....	.....	.....	.....	.....	July 20, 1948	.....	
62.02	May 7, 1948	.....	.....	S	May 7, 1948	.....	
.....	.....	.....	.....	S	May 12, 1948	.....	
102.37	May 12, 1948	.....	.....	S	do	.....	
30.4	Aug. 17, 1949	.....	.....	S	Aug. 17, 1949	.....	
265	Sept. 29, 1952	.....	150	N	Sept. 29, 1952	68+	
56	June 6, 1948	.....	.....	D, S	June 6, 1948	.....	
47	Aug. 25 1948	.....	.....	D, S	Aug. 25, 1948	.....	
40.4	do	.....	.....	S	do	.....	
.....	.....	.....	.....	.....	July 20, 1948	.....	
134.6	Sept. 16, 1948	.....	.....	Ind	Sept. 16, 1948	.....	
79.0	June 10, 1948	.....	.....	N	Sept. 15, 1948	73.5	
.....	.....	.....	30	.....	Jan. 20, 1948	.....	
.....	.....	.....	.....	.....	Feb. 1949	.....	
113.5	Dec. 10, 1936	.....	.....	S	Dec. 10, 1936	.....	
32.3	Nov. 4, 1936	.....	2	D, S	Nov. 4, 1936	.....	
.....	.....	.....	14	D	Feb. 24, 1939	.....	
342	1938	.....	5	.....	Nov. 9, 1938	.....	
126	1950	.....	.....	D	Dec. 18, 1950	.....	
.....	.....	.....	.....	.....	Aug. 3, 1943	.....	
.....	.....	.....	50	.....	.....	.....	
.....	.....	.....	.....	.....	Jan. 3, 1944	.....	
.....	.....	.....	533	P	June 13, 1944	138	
.....	.....	.....	.....	.....	Nov. 2, 1950	.....	
.....	.....	.....	1,158	P	June 18, 1942	115	
.....	.....	.....	.....	.....	June 22, 1942	.....	
82	Feb. 3, 1940	.....	1,000	P	June 20, 1942	.....	
.....	.....	.....	930	P	June 26, 1942	104	
374.1	Aug. 13, 1951	.....	6	S	June 18, 1952	72	
220.4	Jan. 10, 1951	.....	10	S	Jan. 10, 1951	74½	
149.4	Sept. 20, 1951	.....	8	S	Sept. 20, 1951	74	
139.9	Nov. 6, 1950	.....	5	D, S	Sept. 6, 1950	73	
80.7	Aug. 16, 1950	.....	20	D, S	Aug. 15, 1950	.....	
243.1	Oct. 11, 1950	.....	30	S	Jan. 14, 1942	.....	
.....	.....	.....	.....	D, S	Aug. 3, 1952	.....	

Table 2. —*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
K-22	22 mi. NW from San Antonio	Bexar	333		Glen Rose limestone
K-23	14 mi. N from New Braunfels	Comal	154		do
K-24	do	do	221	6	do
K-25	5 mi. E from Dripping Springs	Hays	440		do
K-26	7 mi. NW from Austin	Travis	940	6	do
K-27	13 mi. NW from Belton	Bell	265		do
K-28	Temple	do	1,900		do
K-29	Marlin	Falls	3,378		do
K-30	1 mi. N from Gordonville	Grayson	345		do
K-31	7 mi. SW from Meridian	Bosque	400		Paluxy sand
K-32	Hillsboro	Hill	833	13	do
K-33	Mertens	do	1,400	8	do
K-34	Seagoville	Dallas	2,863		do
K-35	do	do	2,790		do
K-36	do	do	2,778		do
K-37	16 mi. N from Weatherford	Parker	80	5	do
K-38	15 mi. NW from Weatherford	do	22	5	do
K-39	10 mi. N from Fort Stockton	Pecos	200		Trinity group
K-40	13 mi. N from Fort Stockton	do	200	8	do
K-41	18 mi. SW from Rankin	Upton	150		do
K-42	Rankin	do	160	7	do
K-43	do	do	170	8	do
K-44	Santa Rita	Reagan	440	6	do
K-45	Texon	do	400		do
K-46	do	do			do
K-47	Big Lake	do	535	6, 7	do
K-48	17 mi. SW from Hondo	Medina	4,200	7	do
K-49	Von Ormy	Bexar	4,518	5	do
K-50	7 mi. NW from Boerne	Kendall	1,982	8¼	do
K-51	2 mi. E from Dripping Springs	Hays	799		do
K-52	Manor	Travis	3,001	8	do
K-53	11 mi. NW from Austin	do	926		do
K-54	Bartlett	Williamson	1,320	10	do
K-55	Taylor	do	3,260	10	do
K-56	Holland	Bell	1,985		do
K-57	Belton	do	1,172		do
K-58	7 mi. S from Killeen	do	250		do
K-59	Copperas Cove	Coryell	640	4	do
K-60	Gatesville	do	768	8	do
K-61	Evant	do	520	6	do
K-62	17 mi. SE from Gatesville	do	370		do
K-63	5 mi. SE from Gatesville	do	505		do
K-64	Chilton	Falls	2,709	10, 6	do
K-65	19 mi. W from Waco	McLennan	355		do
K-66	Leroy	do	2,311	6, 4	do
K-67	Aquilla	Hill	1,400		do
K-68	Malone	do	2,471	13, 6⅝	do
K-69	Abbott	do	1,850	12, 2	do
K-70	Milford	Ellis	2,000-	8	do
K-71	Waxahachie	do	2,950	6	do
K-72	6½ mi. W from Weatherford	Parker	110	4	do
K-73	14 mi. NW from Fort Worth	Tarrant	340		do
K-74	McKinney	Collin	3,230	13⅜	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	.....	Aug. 30, 1951	.....	
41.0	Dec. 8, 1944	.....	.....	S	Dec. 8, 1944	.....	
.....	.....	3	.....	D, S	Sept. 29, 1944	.....	
.....	.....	.....	.....	D	Feb. 19, 1953	.....	
.....	.....	.....	.....	.....	May 17, 1949	.....	
.....	.....	.....	.....	D, S	Sept. 28, 1950	.....	
.....	.....	.....	.....	P	Jan. 3, 1944	.....	
.....	.....	.....	.....	.....	Feb. 23, 1938	134	
.....	.....	.....	10	.....	Aug. 23, 1953	.....	
.....	.....	.....	.....	.....	Feb. 1952	.....	
150	1941	.....	65	P	1941	.....	
.....	.....	.....	80	P	Jan. 1943	.....	
.....	.....	.....	328	.....	July 11, 1944	119	
.....	.....	.....	.....	.....	Oct. 4, 1944	.....	
.....	.....	.....	566	.....	Nov. 1944	114	
52.0	Nov. 25, 1949	.....	.....	D	Nov. 25, 1949	.....	
15.2	Dec. 20, 1949	.....	.....	D, S	Dec. 20, 1949	.....	
.....	.....	.....	2	.....	Aug. 13, 1950	.....	
27.35	Dec. 6, 1946	.....	2	S	.....do.....	69½	
.....	.....	.....	.....	.....	Mar. 29, 1952	.....	
.....	.....	.....	60	P	Sept. 22, 1948	.....	
.....	.....	.....	50	P	.....do.....	.....	
.....	.....	.....	.....	P	Sept. 11, 1947	69½	
.....	.....	.....	.....	P, Ind	.....do.....	80	
.....	.....	.....	.....	P, Ind	.....do.....	69	
.....	.....	.....	140	P	.....do.....	69	
.....	.....	26	.....	S	Nov. 28, 1951	86	
.....	.....	250	.....	.....	Sept. 25, 1951	.....	
.....	.....	.....	.....	D, S	Feb. 8, 1940	.....	
.....	.....	.....	.....	.....	Aug. 26, 1952	.....	
.....	.....	110	.....	P	Dec. 23, 1946	110	
.....	.....	.....	.....	D	July 2, 1953	.....	
.....	.....	35	.....	P	Feb. 5, 1941	.....	
.....	.....	526	.....	P	Feb. 3, 1941	115	
.....	.....	.....	40	P	Apr. 22, 1943	.....	
.....	.....	.....	700	P	June 24, 1943	.....	
.....	.....	.....	.....	.....	Sept. 27, 1941	.....	
140	June 3, 1946	.....	50	P	June 3, 1946	.....	
138	.....do.....	.....	.....	P	.....do.....	77	
.....	.....	.....	9	P	June 4, 1945	72	
.....	.....	.....	.....	D, S	Oct. 20, 1953	.....	
.....	.....	.....	2	.....	Sept. 23, 1942	.....	
.....	.....	500	.....	D, S, P	June 13, 1944	112	
45	Apr. 15, 1940	.....	.....	.....	Apr. 15, 1940	.....	
45	.....do.....	20	.....	P	Jan. 8, 1943	114	
.....	.....	.....	.....	P	Jan. 1943	.....	
.....	.....	50	.....	P	.....do.....	.....	
90	1942	33	.....	P	.....do.....	.....	
35	Mar. 1942	.....	65	P	.....do.....	.....	
40	Jan. 1943	.....	250	P	.....do.....	.....	
34.1	Nov. 9, 1949	.....	.....	D	Nov. 22, 1949	.....	
.....	.....	.....	.....	.....	Nov. 1, 1950	.....	
82	Mar. 26, 1952	.....	645	P	Mar. 26, 1952	99	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
K-75	Brackettville	Kinney	280		Edwards limestone and associated limestone
K-76	7 mi. E from Brackettville	do	312		do
K-77	12 mi. NE from Uvalde	Uvalde	668	7	do
K-78	24 mi. NW from Hondo	Medina	385	6	do
K-79	12 mi. NE from San Antonio	Bexar	1,355		do
K-80	10 mi. N from San Antonio	do	700	16	do
K-81	Schertz	Guadalupe	2,350	8, 5	do
K-82	2 mi. SW from New Braunfels	Comal	513		do
K-83	10 mi. NE from San Marcos	Hays	450	6	do
K-84	14 mi. NE from San Marcos	do	650	6	do
K-85	12 mi. S from Austin	Travis	390	8	do
K-86	4 mi. S from Austin	do	651		do
K-87	9 mi. N from Austin	do	400		do
K-88	Hutto	Williamson	790	8	do
K-89	2 mi. NE from Thorndale	Milam	2,498	8	do
K-90	14 mi. SE from Tahoka	Lynn	27	16	do
K-91	8 mi. SW from Balmorhea	Jeff Davis	Spring		do
K-92	4 mi. SW from Balmorhea	Reeves	Spring		do
K-93	do	do	Spring		do
K-94	18 mi. E from Waco	McLennan	2,500±		Woodbine sand
K-95	15 mi. SE from Waco	do	3,010		do
K-96	Irene	Hill	915	5	do
K-97	Bynum	do	760	10, 4	do
K-98	Mertens	do	1,400	8	do
K-99	10 mi. NE from Hillsboro	do	538		do
K-100	Corsicana	Navarro	2,477	10	do
K-101	Emhouse	do	2,017	6, $3\frac{3}{4}$	do
K-102	Frost	do	1,184	8, 6	do
K-103	Blooming Grove	do	1,488	$6\frac{5}{8}$, $5\frac{3}{16}$	do
K-104	Ferris	Ellis	1,408	8	do
K-105	Forreston	do	750+	4	do
K-106	Ennie	do	1,796	13	do
K-107	do	do	1,796	20, $8\frac{1}{4}$	do
K-108	North Arlington	Tarrant	51		do
K-109	Mesquite	Dallas	2,555	$8\frac{5}{8}$, $5\frac{1}{2}$	do
K-110	Dallas	do	819	11	do
K-111	Crandall	Kaufman	2,400	6, 4	do
K-112	Forney	do	2,051	6	do
K-113	Rockwall	Rockwall	1,840	6, $3\frac{1}{2}$	do
K-114	Plano	Collin	1,180	$12\frac{1}{2}$, 10, $8\frac{1}{4}$	do
K-115	Anna	do	1,065	6	do
K-116	Melissa	do	1,462	4	do
K-117	Princeton	do	1,475	6	do
K-118	Van Alstyne	Grayson	1,155	8, 6	do
K-119	Clarksville	Red River	602	16, 8	Blossom sand
K-120	Lone Oak	Hunt	521		Nacatoch sand
K-121	2 mi. W from Commerce	do	181	$5\frac{5}{8}$	do
K-122	do	do	180		do
K-123	12 mi. NW from Sulphur Springs	Hopkins	480		do
K-124	3 mi. SW from Malta	Bowie	508	3, $1\frac{1}{2}$	do
K-125	14 mi. SW from Clarksville	Red River	408	20, $10\frac{3}{4}$	do
E-1	Laredo	Webb	2,442		Wilcox group
E-2	Luling	Caldwell	519	12	do
E-3	do	do	304	16, 8	do
E-4	11 mi. SW from Bastrop	Bastrop	97	6	do
E-5	Bastrop	do	680	10	do
E-6	McDade	do	96	4	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	.....	Apr. 8, 1938	.....	
.....	.....	.....	.....	.....	Apr. 9, 1938	.....	
170.31	Apr. 13, 1953	.....	7	P	Apr. 14, 1953	.....	
259.2	Jan. 10, 1951	.....	11	D, S	Jan. 10, 1951	.....	
.....	.....	.....	.....	.....	Jan. 25, 1951	.....	
146.70	July 24, 1946	.....	.....	N	Oct. 11, 1939	.....	
37	Apr. 14, 1947	.....	.....	P	Apr. 14, 1947	.....	
20	Sept. 16, 1941	.....	.....	.....	Sept. 16, 1941	.....	
.....	.....	.....	.....	S	Aug. 26, 1952	.....	
179.5	Sept. 5, 1952	.....	.....	S	do	.....	
20	.....	.....	.....	D, S	Sept. 12, 1949	.....	
.....	.....	.....	.....	N	Aug. 8, 1949	.....	
.....	.....	.....	.....	D, S	Oct. 14, 1949	.....	
65	July 10, 1940	.....	.....	P	Oct. 1951	.....	
Flows	Aug. 8, 1936	700	.....	Ind	Aug. 3, 1936	120	
7.5	Aug. 8, 1949	.....	.....	P	May 17, 1950	.....	
.....	.....	.....	.....	.....	Oct. 28, 1930	.....	
.....	.....	.....	.....	.....	do	.....	
.....	.....	.....	.....	.....	Dec. 6, 1930	.....	
.....	.....	.....	.....	.....	July 1950	.....	
.....	.....	.....	.....	.....	Feb. 1949	.....	
50	1942	.....	50	P	Jan. 15, 1943		
.....	.....	.....	15	P	Jan. 14, 1943	.....	
.....	.....	.....	80	P	do	.....	
.....	.....	.....	.....	S, Irr	Mar. 15, 1953	.....	
81	1938	.....	.....	P	May 1, 1938	.....	
+25	Nov. 7, 1917	.....	.....	P	Feb. 22, 1944	.....	
.....	.....	.....	60	P	do	92	
.....	.....	.....	100	P	do	.....	
.....	.....	.....	.....	P	Jan. 27, 1943	.....	
30	Jan. 27, 1943	.....	.....	P	do	.....	
162	Jan. 6, 1937	.....	520	P	do	.....	
.....	.....	.....	446	P	Jan. 1943	.....	
17.6	Aug. 18, 1953	.....	.....	.....	Aug. 18, 1953	.....	
62	Feb. 25, 1941	.....	260	P	July 31, 1941	.....	
.....	.....	.....	250	Ind	July 11, 1949	85	
55	1943	.....	7	P	July 30, 1943	95	
65	1942	.....	100	P	do	100	
.....	.....	.....	35	P	July 31, 1941	.....	
292	Feb. 1949	.....	160	P	Feb. 20, 1943	85	
148.70	Mar. 21, 1943	.....	50	P	Feb. 19, 1943	.....	
146	Feb. 22, 1940	.....	30	P	do	.....	
.....	.....	.....	50	P	do	.....	
.....	.....	.....	90	P	Feb. 22, 1943	.....	
144	.....	.....	650	P	Sept. 21, 1943	73	
.....	.....	.....	60		Aug. 11, 1942	.....	
.....	.....	.....	.....	.....	Nov. 12, 1943	.....	
.....	.....	.....	2	.....	Nov. 2, 1943	67½	
.....	.....	.....	.....	.....	Jan. 31, 1953	.....	
.....	.....	2	.....	S	Jan. 22, 1945	.....	
.....	.....	.....	500	P	May 21, 1942	68	
.....	.....	.....	.....	N	Aug. 2, 1953	108	Test well
.....	.....	.....	650	Ind	Feb. 7, 1946	80	
.....	.....	.....	300	P	Feb. 1943	.....	
69.2	Mar. 30, 1953	.....	6	D	July 8, 1952	.....	
.....	.....	.....	.....	N	June 11, 1942	.....	
69.3	Feb. 3, 1953	.....	.....	N	Feb. 2, 1946	.....	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
E-7	5 mi. W from Elgin	Bastrop	240		Wilcox group
E-8	5 mi. E from Elgin	do	63	36	do
E-9	10 mi. W from Bryan	Brazos	1,500	12½	do
E-10	Jacksonville	Cherokee	1,139		do
E-11	2 mi. W from Longview	Gregg	290		do
E-12	Kilgore	do	875	15½, 8¼	do
E-13	do	do	906	10, 6⅝	do
E-14	do	do	780	16, 10	do
E-15	1 mi. SE from Waskom	Harrison	200	6	do
E-16	13 mi. NW from Daingerfield	Morris	39	8	do
E-17	12 mi. SW from Carrizo Springs	Dimmit	475	6	Indio formation
E-18	10 mi. NW from Carrizo Springs	do	200		do
E-19	10 mi. W from Carrizo Springs	do			do
E-20	16 mi. W from La Pryor	Zavalla	74		do
E-21	20 mi. SW from Hondo	Medina	400	8	do
E-22	12 mi. S from Hondo	do	55	7	do
E-23	13 mi. SW from Hondo	do	300	6	do
E-24	10 mi. SE from Hondo	do	49	7½	do
E-25	11 mi. SE from Hondo	do	145	10	do
E-26	Laredo	Webb	1,945		Carrizo sand
E-27	7 mi. SE from Carrizo Springs	Dimmit	677	10	do
E-28	21 mi. SE from Carrizo Springs	do	1,432	10	do
E-29	4 mi. NE from Carrizo Springs	do	582	8	do
E-30	Catarina	do	1,334	12½, 10	do
E-31	23 mi. S from Cotulla	La Salle	4,200		do
E-32	21 mi. SW from Tilden	McMullen	4,150		do
E-33	Campbellton	Atascosa	4,130	18, 10¾	do
E-34	3 mi. NW from Campbellton	do	3,600±	8	do
E-35	4 mi. N from Poteet	do			do
E-36	Gordendale	La Salle	2,360	14, 2	do
E-37	10 mi. SE from San Antonio	Bexar	200		do
E-38	Sutherland Springs	Wilson	30+		do
E-39	1 mi. S from Delhi	Caldwell	171	2	do
E-40	8 mi. NE from Smithville	Bastrop	800	4½, 2	do
E-41	15 mi. NE from Bastrop	do	449	4	do
E-42	Giddings	Lee	1,364	12, 6	do
E-43	7 mi. NE from Lufkin	Angelina	3,000±	10	do
E-44	14 mi. SE from Lufkin	do	2,186	4	do
E-45	21 mi. SE from Carrizo Springs	Dimmit	70	6	Bigford member
E-46	3 mi. NE from Carrizo Springs	do	435	8	do
E-47	Laredo	Webb	1,481		Queen City sand member
E-48	13 mi. S from Jourdanton	Atascosa	1,200		do
E-49	20 mi. NE from Floresville	Wilson	263	5	do
E-50	16 mi. S from Bastrop	Bastrop	260	3	do
E-51	13 mi. SE from Caldwell	Burleson	1,100		do
E-52	Bryan	Brazos	875		do
E-53	7 mi. W from Lufkin	Angelina	523	6	do
E-54	Fowlerton	La Salle	1,700	8	Mount Selman formation
E-55	Pearsall	Frio	130	8	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
36	Feb. 10, 1953	.....	.....	.....	Feb. 10, 1953	.....	
57.6	Aug. 3, 1950	.....	.....	D, S	Aug. 3, 1950	.....	
.....	.....	200	.....	S	Nov. 13, 1937	.....	
181	Nov. 8, 1948	.....	.....	.....	Nov. 8, 1948	.....	
145.0	Mar. 30, 1936	.....	50	D	Mar. 30, 1936	.....	
162	Sept. 3, 1941	.....	285	P	May 24, 1943	.....	
157	.....do.....	.....	350	P	.....do.....	80	
111	Sept. 14, 1934	.....	615	P	.....do.....	.....	
.....	.....	.....	.....	D, Ind	Oct. 29, 1941	.....	
36.51	Mar. 17, 1942	.....	.....	D, S	Mar. 17, 1942	.....	
.....	.....	.....	.....	D, S	May 20, 1930	.....	
.....	.....	.....	.....	S	July 18, 1949	.....	
.....	.....	.....	.....	S	.....do.....	.....	
.....	.....	.....	.....	.....	Oct. 2, 1950	.....	
162.4	Aug. 23, 1951	.....	.....	D, S	Aug. 23, 1951	.....	
53.2	July 24, 1951	.....	.....	D, S	Aug. 24, 1951	.....	
106.5	Aug. 23, 1951	.....	.....	S	Aug. 23, 1951	76	
44.7	Sept. 19, 1951	.....	.....	D, S	Sept. 19, 1951	.....	
80.8	Aug. 20, 1951	.....	.....	D, S	Aug. 20, 1951	.....	
.....	.....	5	.....	.....	July 30, 1953	104	
.....	.....	.....	.....	D, S	June 4, 1930	.....	
24.2	Oct. 15, 1930	.....	.....	N	Apr. 17, 1930	94	
35.7	Dec. 4, 1937	.....	.....	Irr	Mar. 1947	.....	
103	Dec. 22, 1938	.....	600	P	May 11, 1945	96	
.....	.....	500	.....	Irr	Sept. 15, 1942	.....	
.....	.....	.....	.....	.....	.....do.....	.....	
.....	.....	975	.....	P	Mar. 14, 1951	138	
+40.5	May 25, 1944	.....	.....	S	May 25, 1944	109½	
.....	.....	.....	.....	.....	Feb. 28, 1940	.....	
.....	.....	.....	40	.....	Jan. 1913	.....	
.....	.....	.....	.....	P	Sept. 8, 1953	.....	
.....	.....	.....	.....	D	June 8, 1911	.....	
88.0	Apr. 26, 1946	.....	.....	D	Apr. 26, 1946	71½	
65.8	Dec. 31, 1952	.....	.....	S	Dec. 31, 1952	75	
110.3	Feb. 13, 1953	.....	2	D, S	Feb. 13, 1953	.....	
160	.....	.....	100	P	Feb. 18, 1944	94½	
+7.0	Feb. 11, 1937	15	.....	N	Feb. 11, 1937	.....	
+1.0	.....do.....	2	.....	S	.....do.....	.....	
.....	.....	.....	.....	.....	May 16, 1940	.....	
64.0	May 15, 1930	.....	.....	.....	May 6, 1930	.....	
.....	.....	.....	.....	N	July 27, 1953	.....	Test well
.....	.....	.....	15	.....	Mar. 11, 1949	.....	
28	Apr. 17, 1952	.....	.....	D, S	May 17, 1952	.....	
88.4	Jan. 23, 1953	.....	.....	N	Jan. 29, 1952	.....	
.....	.....	.....	.....	.....	Nov. 2, 1939	.....	
.....	.....	.....	.....	P	Dec. 7, 1937	87	
.....	.....	4	.....	Ind	Jan. 19, 1937	.....	
38.4	Aug. 1934	.....	235	P	May 11, 1945	81	
65	Jan. 18, 1928	.....	.....	D, S, Irr	Jan. 8, 1928	76	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
E-56	13 mi. W from Jourdanton	Atascosa	227		Mount Selman formation
E-57	13 mi. SW from Jourdanton	do	588		do
E-58	Christine	do	1,314	6, 4	do
E-59	McCoy	do	900		do
E-60	Paige	Bastrop	170		do
E-61	2 mi. SW from Giddings	Lee	210		Sparta sand
E-62	3 mi. NW from Caldwell	Burleson	178	4	do
E-63	Somerville	do	820		do
E-64	35 mi. SE from Lufkin	Angelina	1,510	6	do
E-65	Hemphill	Sabine	631	8, 6	do
E-66	4 mi. SE from Laredo	Webb	145		Upper part of Claiborne group
E-67	10 mi. SE from Cotulla	La Salle	250		do
E-68	5 mi. SE from Cotulla	do	75		do
E-69	Stockdale	Wilson	614		do
E-70	8 mi. N from Tilden	McMullen	Spring		do
E-71	Somerville	Burleson	198	8	do
E-72	Lyons	do	397	4	do
E-73	18 mi. SE from Lufkin	Angelina	541	10	do
E-74	15 mi. SE from Lufkin	do	435	4	do
E-75	12 mi. NW from Jasper	Jasper	1,400	6	do
E-76	24 mi. NW from Jasper	do	1,249		do
E-77	15 mi. NE from Jasper	do	1,320	8	do
E-78	23 mi. NW from Rio Grande City	Starr	250	$4\frac{1}{4}$	Jackson group
E-79	19 mi. NW from Rio Grande City	do	700	8	do
E-80	10 mi. NW from Rio Grande City	do	275	6	do
E-81	6 mi. NE from Whitsett	Live Oak	454	4	do
E-82	13 mi. NE from Huntsville	Walker	395	4	do
E-83	14 mi. NE from Huntsville	do	2,800	10	do
E-84	11 mi. S from Lufkin	Angelina	74	6	do
M-1	11 mi. S from Linn	Hidalgo	1,430	7	Catahoula and Oakville sandstones
M-2	7 mi. S from Linn	do	1,464	12	do
M-3	15 mi. N from Rio Grande City	Starr	381	$4\frac{1}{4}$	do
M-4	25 mi. NW from Rio Grande City	do	100	5	do
M-5	Hebbronville	Jim Hogg	1,198	8, 6	do
M-6	Freer	Duval	570	7	do
M-7	do	do	700	7	do
M-8	do	do	450	7	do
M-9	Concepcion	do	288	6	Lagarto clay
M-10	George West	Live Oak	500	10	Catahoula and Oakville sandstones
M-11	Beeville	Bee	1,539	$12\frac{3}{4}$, $6\frac{5}{8}$	do
M-12	Pettus	do	367	$8\frac{1}{4}$, $6\frac{5}{8}$	do
M-13	Kenedy	Karnes	400	$13\frac{3}{8}$, $6\frac{5}{8}$	do
M-14	Karnes City	do	860	12	do
M-15	Cuero	De Witt	1,207	$12\frac{3}{4}$, $6\frac{5}{8}$	do
M-16	4 mi. SE from Hallettsville	Lavaca	100	4	do
M-17	13 mi. NE from Huntsville	Walker	135	4	do
M-18	Onalaska	Polk	350	8	do
M-19	do	do	320	3	do
O-1	4 mi. N from Midland	Midland	127	$12\frac{1}{2}$	Ogallala formation

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	10	.....	Mar. 9, 1949	.....	
.....	.....	.....	10	.....	Mar. 8, 1949	.....	
+25	1929–30	300	.....	P	May 25, 1944	.....	
.....	.....	.....	.....	P	Aug. 14, 1945	91	
.....	.....	.....	.....	.....	June 28, 1911	.....	
88	Mar. 22, 1952	.....	120	D, Irr	Mar. 22, 1952	.....	
10	July 28, 1951	.....	.....	D	July 28, 1951	.....	
.....	.....	.....	.....	.....	Nov. 28, 1939	.....	
.....	.....	.....	.....	P	Apr. 1, 1937	.....	
99.75	May 8, 1942	.....	40	P	May 22, 1942	80	
.....	.....	.....	.....	.....	Oct. 18, 1938	.....	
.....	.....	.....	.....	.....	July 1952	.....	
20	Oct. 4, 1950	.....	.....	.....	Oct. 4, 1950	.....	
460+	Feb. 11, 1911	.....	.....	.....	Feb. 11, 1911	.....	
.....	.....	.....	.....	S	July 6, 1948	.....	
60	Nov. 2, 1939	.....	150	P	Nov. 2, 1939	.....	
97	Sept. 1939	.....	.....	D, S	Nov. 3, 1939	.....	
27.23	Feb. 12, 1937	.....	.....	.....	Feb. 22, 1937	.....	
39.04	Feb. 18, 1937	.....	.....	.....	Feb. 18, 1937	.....	
.....	.....	.....	.....	S	Apr. 11, 1908	65	
.....	.....	.....	.....	.....	Sept. 12, 1907	.....	
.....	.....	.....	60	.....	1914	.....	
214.5	Nov. 2, 1950	.....	.....	S	Nov. 2, 1950	81½	
.....	.....	.....	.....	S	Oct. 31, 1950	81	
212.9	Oct. 16, 1950	.....	.....	D, S	Oct. 16, 1950	.....	
80	Aug. 1940	.....	9	Ind	Aug. 16, 1940	.....	
80	Sept. 14, 1948	.....	.....	D, Ind	Sept. 14, 1948	77½	
.....	.....	0.5	.....	S	Oct. 15, 1948	.....	
+14	Feb. 17, 1937	40	.....	Ind	Feb. 17, 1937	.....	
+23	June 10, 1947	275	750	Irr	Mar. 24, 1948	.....	
+16.3	Mar. 20, 1948	.....	.....	Irr	Jan. 24, 1948	.....	
44.2	Oct. 16, 1950	.....	.....	S	Oct. 16, 1950	78	
47.4	Oct. 18, 1950	.....	.....	S	Oct. 18, 1950	79	
35	Aug. 8, 1945	.....	135	P	Aug. 8, 1945	.....	
165	Mar. 6, 1945	.....	30	P	Mar. 6, 1945	89	
200	.....do.....	.....	20	P	.....do.....	78	
165+	.....do.....	.....	15	P	.....do.....	88½	
49.5	June 13, 1931	.....	.....	D, S	June 13, 1931	.....	
38.4	Aug. 1934	.....	235	P	Apr. 19, 1945	81	
68	Apr. 19, 1945	.....	490	P	.....do.....	95	
.....	.....	.....	40	P	Apr. 18, 1945	.....	
90	July 25, 1943	.....	375	P	.....do.....	79	
.....	.....	.....	175	P	Apr. 17, 1945	92	
19+	Dec. 22, 1944	325	.....	P	Dec. 22, 1944	91	
45	Mar. 24, 1951	.....	6	.....	Mar. 24, 1951	.....	
80	Sept. 14, 1948	.....	.....	D, Ind	Sept. 10, 1948	77½	
0.0	Mar. 15, 1947	1	.....	S	Mar. 15, 1947	70	
23	1942	.....	.....	D, S	June 12, 1947	.....	
35.02	Nov. 11, 1947	.....	700	Irr	July 28, 1949	69	

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
O-2	2 mi. N from Midland	Midland	140		Ogallala formation
O-3	3 mi. E from Midland	do	107	18	do
O-4	22 mi. SE from Andrews	Andrews	57	$6\frac{5}{8}$	do
O-5	5 mi. NW from Stanton	Martin	100		do
O-6	Coahoma	Howard	50	48	do
O-7	13 mi. NE from Lamesa	Dawson	70		do
O-8	9 mi. NW from Gail	Borden	46		do
O-9	16 mi. NW from Gail	do	60	4	do
O-10	7 mi. NW from Ira	Scurry	125		do
O-11	Plains	Yoakum	128	12	do
O-12	18 mi. NE from Seminole	Gaines	60	6	do
O-13	Wellman	Terry	142	6	do
O-14	Tokio	do	120	5	do
O-15	15 mi. NE from Tahoka	Lynn	128	16	do
O-16	7 mi. NE from Tahoka	do	200	5	do
O-17	2 mi. N from Tahoka	do	99	16	do
O-18	15 mi. SW from Tahoka	do	82	6	do
O-19	14 mi. SW from Tahoka	do	117	6	do
O-20	Anton	Hockley	115	12	do
O-21	Lubbock	Lubbock	135	22, 18	do
O-22	do	do	150	22, 18	do
O-23	12 mi. E from Amherst	Lamb	208	16	do
O-24	10 mi. E from Amherst	do	198	16	do
O-25	6 mi. SW from Amherst	do	100	5	do
O-26	8 mi. SE from Clarendon	Donley	136		do
O-27	7 mi. NW from Clarendon	do	127		do
O-28	Adrian	Oldham	496	7	do
O-29	Pampa	Gray	450	16	do
O-30	1 mi. S from Sebastian	Cameron	329	$12\frac{3}{4}$	Goliad sand
O-31	4 mi. NE from Santa Rosa	do	697	12	do
O-32	4 mi. N from Santa Rosa	do	390	12	do
O-33	Lyford	Willacy	1,935	10, 8	do
O-34	Raymondville	do	1,196		do
O-35	McAllen	Hidalgo	438		do
O-36	Donna	do	460		do
O-37	Weslaco	do	465		do
O-38	Edcouch	do	338		do
O-39	Edinburg	do	349		do
O-40	16 mi. N from Rio Grande City	Starr	530	$4\frac{1}{4}$	do
O-41	10 mi. N from Rio Grande City	do	204	$5\frac{1}{2}$	do
O-42	8 mi. S from Hebbroville	Jim Hogg	2,005	12	do
O-43	12 mi. W from Armstrong	Kenedy	960	5, $3\frac{3}{16}$	do
O-44	Kingsville	Kleberg	725	8^{16}	do
O-45	34 mi. E from Laredo	Webb	125		do
O-46	San Diego	Duval	240	6	do
O-47	Benavides	do	615	8^{5}	do
O-48	Alice	Jim Wells	992	16, 8^{8}	do
O-49	4 mi. SW from Alice	do	620		do
O-50	Orange Grove	do	288	8	do
O-51	26 mi. W from Corpus Christi	Nueces	596		do
O-52	Mathis	San Patricio	319		do
O-53	Sinton	do	936	6	do
O-54	do	do	940	8	do
O-55	14 mi. SE from George West	Live Oak	200	12	do
O-56	6 mi. SW from Angleton	Brazoria	1,000	6	Lissie formation
O-57	3 mi. NW from Alta Loma	Galveston	1,221	4	do
O-58	10 mi. SE from Houston	Harris	1,676	4	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	.....	Aug. 23, 1946	.....	
53.39	Sept. 25, 1947	.....	350	P	May 26, 1944	67½	
38.17	Dec. 11, 1947	.....	.....	S	Dec. 11, 1947	.....	
.....	.....	.....	325	Irr	July 14, 1953	.....	
.....	.....	.....	125	P	Aug. 22, 1947	.....	
.....	.....	.....	.....	.....	Nov. 1949	.....	
29.0	June 29, 1948	.....	.....	D, S	June 29, 1948	.....	
30	Sept. 16, 1948	.....	.....	D, S	Sept. 16, 1948	66	
88.9	May 11, 1948	.....	.....	S	May 11, 1948	.....	
72	1940	.....	150	P	Oct. 30, 1944	.....	
45.8	Aug. 12, 1938	.....	.....	D, S	Aug. 12, 1938	.....	
130	1944	.....	.....	S	May 23. 1944	.....	
89.87	June 20, 1944	.....	.....	S	June 20, 1944	.....	
.....	.....	.....	425	Irr	July 28, 1949	65	
140	July 8, 1949	.....	.....	S	.....do.....	.....	
62.8	Aug. 3, 1949	.....	625	Irr	Aug. 3, 1949	.....	
61.3	Aug. 16, 1949	.....	.....	D, S	Aug. 16, 1949	68½	
110.9	June 1950	.....	3	Irr	May 17, 1950	64½	
.....	.....	.....	185	P	Mar. 13, 1947	.....	
59.4	Sept. 26, 1944	.....	535	P	Oct. 2, 1944	.....	
53.7	.....do.....	.....	640	P	Sept. 22, 1944	.....	
81.5	Aug. 25, 1950	.....	900	Irr	Apr. 3, 1952	.....	
.....	.....	.....	.....	Irr	.....do.....	.....	
20.0	Apr. 18, 1952	.....	.....	S	Apr. 18, 1952	.....	
81.8	Aug. 24, 1949	.....	.....	S	Aug. 24, 1949	.....	
124.85	Sept. 21, 1949	.....	.....	S	Sept. 21, 1949	.....	
455	Nov. 20, 1947	.....	18	P	Nov. 20, 1947	64	
347	1947	.....	600	P	.....do.....	.....	
18	July 1952	.....	.....	Irr	July 24, 1952	.....	
6	Jan. 1952	.....	900	Irr	Jan. 16, 1952	.....	
22.3	Sept. 11, 1952	.....	650	Irr	Jan. 14, 1952	78	
.....	.....	.....	.....	P	Aug. 7, 1944	92	
.....	.....	.....	812	.....	Sept. 23, 1953	91½	
.....	.....	.....	1,700	.....	Sept. 1, 1953	.....	
.....	.....	.....	.....	.....	Aug. 26, 1953	.....	
.....	.....	.....	1,100	.....	Sept. 18, 1953	.....	
.....	.....	.....	900	.....	.....do.....	.....	
.....	.....	.....	.....	.....	Aug. 27, 1953	.....	
.....	.....	.....	.....	S	Sept. 14, 1950	85	
42.7	Sept. 20, 1950	.....	.....	S	Sept. 20, 1950	.....	
.....	.....	.....	200	S	Mar. 21, 1934	.....	
.....	.....	11	.....	S	.....	.....	
.....	.....	.....	148	P	Feb. 5, 1943	85	
.....	.....	.....	2	.....	Oct. 4, 1951	.....	
140	Feb. 28, 1928	.....	7	D, S	Feb. 28, 1928	.....	
88.69	Mar. 7, 1945	.....	125	P	Mar. 7, 1945	80½	
110	May 8, 1945	.....	375	P	Mar. 5, 1945	86	
.....	.....	.....	.....	.....	.....	.....	
120	June 2, 1945	.....	75	P	June 2, 1945	78½	
.....	.....	.....	.....	.....	June 15, 1949	.....	
.....	.....	.....	280	P	July 1945	.....	
.....	.....	15	.....	P	July 19, 1945	.....	
.....	.....	100	.....	P	.....do.....	.....	
.....	.....	.....	1,200	Irr	Sept. 20, 1951	.....	
.....	.....	.....	.....	D, S	July 1, 1941	.....	
.....	.....	.....	.....	N	Sept. 19, 1952	.....	Test well
243±	Sept. 9, 1953	.....	10	N	Sept. 9, 1953	.....	Do.

Table 2.—*Records of saline water wells*

Well or spring no.	Location	County	Depth of well (feet)	Diameter of well (inches)	Water-bearing unit
O-59	La Porte	Harris	1,158	4	Lissie formation
O-60	Raywood	Liberty	443		do
O-61	5 mi. NW from Dayton	do	834	20, 16	do
O-62	2 mi. SE from Beaumont	Jefferson	620	12¾, 8⅝	do
O-63	18 mi. NW from Orange	Orange	740	6	do
O-64	Sour Lake	Hardin	763		do
B-1	4 mi. N from Brownsville	Cameron	200		Beaumont clay
B-2	1 mi. S from Kingsville	Kleberg	100	5⅜	do
B-3	Odom	San Patricio	126	10	do
B-4	Taft	do	200		do
B-5	do	do	216	24, 16	do
B-6	3 mi. N from Rockport	Aransas	165	4	do
B-7	7 mi. S from Port O'Connor	Calhoun	333	8	do
B-8	8 mi. W from Port Lavaca	do	360	4	do
B-9	6 mi. S from Matagorda	Matagorda	600	2½	do
B-10	12 mi. SE from Bay City	do	744	4, 2	do
B-11	3 mi. W from Freeport	Brazoria	1,100±	3	do
B-12	1 mi. N from Pearland	do	1,773	20, 14	do
B-13	2 mi. SW from Texas City	Galveston	1,000		"Alta Loma" sand
B-14	Alta Loma	do	884	20	do
B-15	Galveston	do	1,317		do
B-16	4 mi. SW from Texas City	do	100	2	Beaumont clay
B-17	5 mi. SW from Galveston	do	279		do
B-18	Winnie	Chambers	192		do
B-19	Anahuac	do	420		do
B-20	9 mi. S from Anahuac	do	546		do
B-21	4 mi. SW from Anahuac	do	487		"Alta Loma" sand
B-22	15 mi. SW from Beaumont	Jefferson	200	2	Beaumont clay
B-23	Orange	Orange	941	4	"Alta Loma" sand
R-1	10 mi. N from El Paso	El Paso	1,200		Alluvium
R-2	10 mi. NE from El Paso	do	1,020	3	do
R-3	Sierra Blanca	Hudspeth	1,000	6	do
R-4	17 mi. NE from Van Horn	Culberson			do
R-5	10 mi. NE from Van Horn	do			do
R-6	Near Orla	do			do
R-7	5 mi. NW from Pecos	Reeves	135	10½	do
R-8	2 mi. NW from Pecos	do	225		do
R-9	1 mi. W from Barstow	Ward	115	8	do
R-10	3 mi. E from Pyote	do	110		do
R-11	Mentone	Loving	246		do
R-12	Colorado City	Mitchell	220		do
R-13	5 mi. E from Stamford	Jones	101	8	do
R-14	1 mi. N from Rochester	Haskell	65	108	do
R-15	Haskell	do	28	240	do
R-16	Goree	Knox	45	144	do
R-17	Munday	do	37	240	do
R-18	Knox City	do	38	240	do
R-19	Red Springs	Baylor			do
R-20	Vernon	Wilbarger	22	18	do
R-21	12 mi. N from Vernon	do	92	18	do
R-22	Paducah	Cottle	127	7	do
R-23	Childress	Childress	400		do
R-24	7 mi. NW from Harlingen	Cameron	40	1½	do
R-25	8 mi. SW from Harlingen	do	35	2	do
R-26	8 mi. NE from Harlingen	do		2	do
R-27	San Juan	Hidalgo	346		do
R-28	Mercedes	do	346		do
R-29	McAllen	do	512	12	do
R-30	Weslaco	do	547		do
R-31	Mission	do	363		do
R-32	Pharr	do	312		do
R-33	24 mi. NW from Rio Grande City	Starr	100	6	do

and springs in Texas—Continued

Reported water level		Yield (gallons per minute)		Use of water	Date of collection of sample	Temperature (°F)	Remarks
Below land surface (feet)	Date of measurement	Flow	Pump				
.....	.....	.....	.....	N	Nov. 17, 1945	.....	Test well
.....	.....	.....	.....	Irr	Sept. 1948	.....	
45	Aug. 1943	.....	2,000	Irr	Apr. 19, 1945	78	
19.79	Sept. 23, 1941	.....	1,130	Ind	Sept. 23, 1941	.....	
.....	.....	2	.....	N	Sept. 26, 1941	.....	
.....	.....	.....	250+	.....	Aug. 5, 1953	.....	
.....	.....	.....	.....	.....	Apr. 21, 1950	.....	
.....	.....	.....	.....	D, S	Feb. 1, 1938	.....	
60	July 1945	.....	60	P	July 1945	.....	
.....	.....	.....	300	P	do.	.....	
70	Nov. 7, 1944	.....	260	P	do.	.....	
.....	.....	.....	.....	D	May 17, 1952	.....	
.....	.....	.....	.....	D	Nov. 18, 1953	.....	Matagorda Island
.....	.....	.....	.....	.....	Sept. 1947	.....	
.....	.....	4	.....	P	June 11, 1943	.....	
.....	.....	.....	.....	D, S	May 1947	.....	
+3	July 11, 1941	25	.....	D, S	July 11, 1941	.....	
82.6	Nov. 15, 1946	.....	1,200	Irr	Nov. 15, 1946	.....	
.....	.....	.....	600	.....	Aug. 26, 1952	.....	
79.1	Apr. 18, 1944	.....	.....	P	Sept. 24, 1952	.....	
.....	.....	.....	2,000	.....	Apr. 10, 1951	.....	
.....	.....	.....	.....	D, S	Apr. 18, 1939	.....	
.....	.....	.....	.....	.....	Jan. 15, 1952	.....	
.....	.....	.....	.....	.....	May 1943	.....	
.....	.....	.....	.....	.....	Dec. 14, 1948	.....	
.....	.....	.....	.....	.....	Dec. 17, 1948	.....	
.....	.....	.....	.....	.....	Apr. 16, 1953	.....	
1.05	May 22, 1941	.....	.....	N	May 22, 1941	.....	
.....	.....	.....	.....	N	June 1945	.....	Test well
379.0	July 22, 1953	.....	.....	N	July 20, 1953	.....	Do.
308.4	Apr. 9, 1954	.....	.....	N	June 1953	.....	Do.
.....	.....	.....	35	P	July 23, 1943	88	
.....	.....	.....	3	Irr	June 30, 1950	.....	
.....	.....	.....	5	Irr	May 4, 1950	.....	
.....	.....	.....	.....	.....	Apr. 19, 1940	.....	
16.9	Nov. 4, 1946	.....	1,200	Irr	Mar. 7, 1950	.....	
.....	.....	.....	.....	Irr	Mar. 28, 1950	69½	
8.0	Oct. 21, 1930	.....	1,000	Irr	Oct. 21, 1930	65	
82.8	Oct. 4, 1940	.....	.....	S	Mar. 1, 1943	.....	
28	.....	.....	.....	.....	Dec. 16, 1940	.....	
.....	.....	.....	32	P	Mar. 6, 1946	.....	
60	July 1953	.....	.....	D, S	July 29, 1953	69½	
42.55	Mar. 24, 1944	.....	750	Irr	Mar. 23, 1944	.....	
19	Mar. 17, 1944	.....	400	P	Mar. 17, 1944	.....	
21.7	Mar. 22, 1944	.....	220	P	Mar. 22, 1944	.....	
13	do.	.....	500	P	do.	.....	
18.5	do.	.....	375	P	do.	.....	
.....	.....	.....	.....	.....	Oct. 1944	.....	
15.89	Oct. 9, 1943	.....	225	P	Oct. 9, 1943	.....	
22.27	Jan. 31, 1952	.....	430	N	Feb. 7, 1952	.....	Do.
33	Sept. 16, 1947	.....	150	P	Mar. 10, 1946	.....	
.....	.....	.....	400	P	Sept. 24, 1945	.....	
.....	.....	.....	.....	Irr	Sept. 19, 1952	77	
8.0	July 9, 1952	.....	.....	Irr	July 9, 1952	.....	
7.0	Nov. 17, 1952	.....	.....	Irr	Nov. 17, 1952	78	
.....	.....	.....	750	P	Aug. 24, 1953	.....	
.....	.....	.....	880	P	June 4, 1953	.....	
60.0	May 26, 1953	.....	815	P	May 26, 1953	80	
.....	.....	.....	900	P, Ind	June 4, 1953	.....	
.....	.....	.....	700	P	July 21, 1953	.....	
50.0	May 25, 1953	.....	550	P	May 25, 1953	81	
92.0	Nov. 1, 1950	.....	.....	D, S	Nov. 1, 1950	82	

Table 3.— *Chemical analyses and related physical measurements of saline surface water in Texas*

[Analyses in parts per million, except as indicated]

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
1.....	Canadian River at Tascosa																	
	max	16	.....	96	62	521		250	604	560	1.0	1.2	.....	1,980	494	70	3,190	7.9
	min	16	.....	26	8.7	71		189	41	40	.....	1.2	.....	297	101	60	515	7.8
	wt avg	18	.....	44	18	147		208	155	121	.8	2.2	.....	622	184	63	1,020	.....
2.....	Canadian River near Amarillo																	
	max	36	.....	177	62	400		272	523	520	4.4	66	.....	1,920	696	56	3,040	8.0
	min	16	.....	21	9.1	90		140	85	56	1.2	1.5	.....	385	90	69	602	7.7
	wt avg	22	.....	48	20	146		202	158	130	1.0	4.9	.....	640	202	61	1,040	.....
3.....	Canadian River near Borger																	
	max	26	.....	698	504	591		200	431	3,180	.4	.....	.....	5,530	3,810	25	9,580	7.8
	min	15	.....	32	12	84		150	95	60	.5	5.0	.....	392	130	58	641	7.8
4.....	Salt Fork Red River near Wellington																	
	max	28	.....	542	101	185		110	1,690	225	.7	2.5	.....	2,830	1,770	19	3,310	7.7
	min	26	.....	141	25	51	.....	125	359	65	.5	1.5	.....	730	455	20	1,080	7.7
5.....	Mulberry Creek near Brice																	
	max	44	.....	472	144	219		79	1,730	270	.....	0.5	.....	2,920	1,770	21	3,480	7.7
	min	18	.....	128	17	43		80	334	49	.....	1.8	.....	693	391	19	918	8.0
6.....	Prairie Dog Town Fork Red River near Brice																	
	max	25	.....	813	217	4,410		153	2,270	7,110	.....	.....	.....	14,900	2,920	77	21,400	7.8
	min	20	.....	202	36	308		110	583	440	.....	3.8	.....	1,650	652	51	2,540	8.0
	wt avg	23	.....	229	44	454		129	669	663	.....	.....	.....	2,140	752	57	3,370	.....

7.....	Pease River near Crowell																	
	max	.....	.....	864	170	4,050		145	2,300	6,480	.....	2.5	.....	14,300	2,860	75	20,400	.....
	min	12	0.12	326	33	134		76	847	208	.6	1.5	0.6	1,600	949	23	2,420	.....
	wt avg	13	.08	424	64	783	16	112	1,130	1,250	.4	3.2	.....	3,740	1,320	57	5,540	.....
8.....	Lake Kemp near Mabelle.....	7.4	.02	240	57	694		106	675	1,100	.4	.0	.....	2,830	834	64	4,650	7.4
9.....	Wichita River at Wichita Falls.....	12	.....	230	61	614		113	629	1,000	.....	2.0	.....	2,600	825	62	4,320	7.4
10.....	Lake Texoma at Perrin AF Base.....	6.3	.01	97	28	243		111	236	388	.3	1.5	.....	1,060	357	60	1,850	7.6
11.....	Red River near Gainesville																	
	max	.....	.....	310	97	1,030		214	751	1,740	.....	3.5	.....	4,040	1,170	66	6,550	.....
	min	.....	.....	49	11	54		[b]125	50	91	.....	1.8	.....	360	168	41	592	.....
	wt avg	.....	.....	97	24	194		137	169	335	.....	3.5	.....	891	340	55	1,540	.....
12.....	Sulphur River near Darden																	
	max	7.5	.....	194	52	1,970		158	733	2,900	.....	.....	.....	5,930	698	86	10,000	.....
	min	5.8	.....	17	1.5	14		66	10	10	.....	1.0	.....	122	49	39	150	.....
	wt avg	7.3	.....	24	3.5	22		81	20	25	.....	1.1	.....	168	74	39	252	.....
13.....	Salt Fork Brazos River near Aspermont																	
	max	11	.....	1,440	274	16,900		159	3,440	26,800	.....	.....	.....	48,900	4,720	89	60,900	7.7
	min	15	.....	166	26	448		116	435	670	.....	4.0	.....	1,820	521	65	3,060	7.8
	wt avg	16	.....	320	52	1,400		117	786	2,230	.....	.....	.....	4,870	1,010	75	7,640	.....
14.....	Double Mountain Fork Brazos River near Aspermont																	
	max	13	.....	614	82	595		116	1,700	920	.....	1.2	.....	3,980	1,870	42	5,350	7.8
	min	16	.....	74	9.6	132		120	240	114	.....	1.0	.....	646	224	56	1,030	7.6
	wt avg	15	.....	162	18	138		109	460	148	.....	2.3	.....	1,010	478	39	1,470	.....
15	Clear Fork Brazos River at Nugent																	
	max	4.1	.....	370	138	774		140	1,460	1,090	.....	2.5	.....	3,910	1,490	53	5,650	7.8
	min	8.8	.....	34	1.1	20		104	32	8.0	.....	2.5	.....	158	89	32	264	7.4
	wt avg	10	.....	65	15	54		120	145	63	.....	2.3	.....	425	224	34	659	.....

See footnotes at end of table.

Table 3.— *Chemical analyses and related physical measutements of saline surface water in Texas*— Continued

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	pH
16.....	Brazos River at Possum Kingdom Dam near Graford																	
	wt avg	13	.....	152	29	388		130	322	636	.....	1.0	.....	1,610	498	63	2,770	.....
17.....	Daniel Salt Lake in Eastland County....	22	.....	8,310	2,080	41,400		43	21	84,500	.....	.....	.....	136,000	29,300	75	131,000	6.9
18.....	Colony Creek in Eastland County																	
		18	.....	1,860	483	6,080		79	166	13,900	.....	.....	.....	22,500	6,630	67	33,300	7.5
		16	.....	318	66	1,010		64	25	2,250	.....	.....	.....	3,720	1,060	67	6,690	7.6
19.....	Rich Lake in Terry County.....	.....	.....	2,500	7,500	18,000		561	40,600	23,700	.....	.....	.....	92,600	37,000	51	.....	.....
20.....	Cedar Lake in Gaines County.....	.....	.....	1,180	2,280	30,100		110	25,000	36,600	.....	.....	.....	95,200	12,300	84	.....	.....
21.....	Colorado River above Bull Creek near Knapp																	
	max	29	.....	510	176	2,250		154	1,310	3,830	.....	.....	.....	8,180	2,000	71	12,500	8.1
	min	13	.....	18	5.1	62		118	50	35	.....	2.5	.....	244	66	67	404	7.9
22.....	Colorado River at Colorado City																	
	max	8.1	.....	641	253	6,180		125	2,060	9,810	.....	.....	.....	19,000	2,640	84	28,100	7.4
	min	10	.....	22	5.0	65		116	35	60	.....	1.8	.....	264	75	65	482	7.8
	wt avg	13	.....	43	13	214		123	89	303	.....	2.5	.....	742	161	74	1,330	.....
23.....	Colorado River at Robert Lee																	
	max	5.1	.....	434	116	1,420	.....	76	1,300	2,230	.....	.....	.....	5,540	1,560	66	8,700	7.4
	min	17	.....	38	6.8	49		107	41	66	.....	6.5	.....	294	123	46	511	7.6
	wt avg	17	.....	69	18	223		197	153	290	.....	3.0	.....	888	246	66	1,510	.....

24.....	Bull Creek near Ira																	
	max	11	.....	111	39	1,000		69	317	1,580	.....	5.0	.....	3,100	438	83	5,510	7.6
	min	12	.....	24	4.6	23		114	17	11	.....	4.0	.....	152	79	39	263	7.4
	wt avg	15	.....	32	6.4	47		134	37	40	.....	3.6	.....	256	106	49	427	.....
25.....	Bluff Creek near Ira																	
	max	17	.....	120	55	662		258	423	930	.....	1.5	.....	2,340	526	73	3,960	8.2
	min	14	.....	32	6.6	19		118	22	18	.....	4.1	.....	195	107	28	297	8.1
26.....	Morgan Creek near Colorado City																	
	max	2.8	.....	238	116	1,540		159	1,130	2,200	.....	.....	.....	5,310	1,070	76	8,540	.....
	min	15	.....	26	5.2	24		104	29	15	.....	1.0	.....	171	86	37	276	7.6
27.....	Rio Grande at El Paso																	
	max	.....	.....	90	30	319	.....	133	421	272	.....	.....	.32	1,400	.....	67	2,020	8.1
	min	.....	.....	69	22	144	.....	88	252	124	.....	1.9	.17	758	.....	53	1,160	7.7
28.....	Rio Grande at Fort Quitman																	
	max	.....	.....	346	125	1,220	.....	87	1,230	2,000	.....	.6	.73	5,160	.....	66	7,650	7.8
	min	.....	.....	66	12	77	.....	65	93	126	.....	2.5	.12	507	.....	44	802	7.9
29.....	Rio Grande at the upper Presidio station																	
	max	.....	.....	498	116	955	.....	215	1,230	1,680	.....	.6	.59	4,890	.....	55	6,960	7.7
	min	.....	.....	45	6.2	56	.....	157	103	17	.....	2.5	.10	353	.....	47	507	7.8
30	Red Bluff Lake on Pecos River in Loving and Reeves Counties.....	1.2	.00	571	227	1,770	48	120	2,090	2,790	1.2	.....	.85	7,560	2,360	61	11,100	7.2
31	Pecos River near Orla																	
	max	23	.....	590	219	1,500		96	2,120	2,380	.....	.....	.....	6,880	2,370	58	10,100	7.2
	min	11	.....	241	34	270		70	635	430	.....	4.5	.....	1,660	742	44	2,560	7.3
	wt avg	21	.....	505	164	813		109	1,750	1,260	.....	1.4	.....	4,580	1,930	48	6,420	.....

See footnotes at end of table.

Table 3.—*Chemical analyses and related physical measurements of saline surface water in Texas*—Continued

No. on plate 9	Source and range of samples[a]	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
32....	Lake Balmorhea on Toyah Creek in Reeves County.....	11	.00	184	92	464	15	245	689	650	1.2	1.2	.45	2,230	838	54	3,330	7.8
33....	Toyah Creek below Toyah Lake near Pecos																	
	max	.....	.....	876	157	2,380		60	4,250	2,510	.....	.....	.....	10,200	2,830	65	13,500	.....
	min	11	.....	408	37	218		38	1,190	265	.....	2.0	.....	2,150	1,170	29	2,780	.....
34....	Pecos River below Grandfalls																	
	max	19	.....	745	372	2,790		191	2,930	4,430	.....	.....	.....	11,400	3,390	64	15,600	7.6
	min	30	.....	627	306	1,990		146	2,530	3,120	.....	.....	.....	8,670	2,820	61	12,200	7.9
	wt avg	22	.....	715	354	2,420		154	2,850	3,840	.....	.....	.....	10,300	3,240	62	14,400	.....
35	Old River near Cove																	
	max	9.8	.....	91	68	667		150	203	1,150	.....	1.2	.....	2,260	506	74	4,190	.....
	min	9.5	.....	32	5.6	22		116	9.9	30	.....	3.2	.....	179	103	32	307	7.7
36	Trinity River at Anahuac																	
	max	13	.....	263	704	4,860		126	1,290	8,990	.....	.....	.....	16,200	3,550	75	25,600	7.7
	min	7.8	.....	17	5.2	34		70	18	42	.....	1.8	.....	184	64	53	286	7.4
37	Laguna Madre at Carolina Beach Pier.....	.....	.....	439	1,260	12,400		244	3,030	21,300	.....	.....	.....	38,500	.....	81	57,000	.....

[a]Maximum and minimum refer to dissolved solids; weighted average refers to all constituents.
[b]Includes equivalent of 8 ppm carbonate (CO_3).

Table 4.—*Records and stream data of saline surface water in Texas*

[Frequency of sampling: D, daily; W, weekly; M, monthly; Inf, infrequently]

No. on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
1.....	Canadian River at Tascosa.....	19,200	16.8 5,645 196	Mar. 2-3, 14-15, 1951 May 14-15, 1951 Nov. 1, 1950 to Sept. 30, 1951	46	D D D	Records available: June 1948 to Sept. 1953
2.....	Canadian River near Amarillo.....	19,287	15.1 533 198	Jan. 21-31, 1951 Aug. 10-12, 1951 Oct. 1, 1950 to Sept. 30, 1951	48	D	Records available: Sept. 14, 1950 to present
3.....	Canadian River near Borger.....	.....	.....	Oct. 2-3, 7-10, 1950 Sept. 21-30, 1951	44	D	Records available: Sept. 14, 1950 to Oct. 15, 1952
4.....	Salt Fork Red River near Wellington.....	.....	.....	Aug. 6, 8, 18-20, 1953 May 11-12, 14, 16-20, 1953	32	D	Records available: June 6, 1952 to present
5.....	Mulberry Creek near Brice.....	534	.25 204	June 24, 1950 July 24, 1950	25	D	Records available: Aug. 1, 1949 to July 31, 1951
6.....	Prairie Dog Town Fork Red River near Brice.	5,646	10.1 6,032 162	Jan. 15, 1951 May 17-20, 1951 Oct. 1, 1950 to Sept. 30, 1951	25	D	Records available: Aug. 1, 1949 to July 31, 1951
7.....	Pease River near Crowell.....	2,940	9.0 1,060 146	Dec. 24, 1942 Apr. 17, 1943 Oct. 1, 1942 to June 3, 1943	22	D	Records available: July 1, 1942 to June 30, 1943
8.....	Lake Kemp near Mabelle.....	.....	.....	June 16, 1952	1	Inf	Miscellaneous sample
9.....	Wichita River at Wichita Falls.....	.....	.....	Oct. 12, 1951	1	Inf	Miscellaneous sample
10.....	Lake Texoma at Perrin AF Base.....	.....	.....	Oct. 1953	1		Miscellaneous sample

Table 4.—*Records and stream data of saline surface water in Texas*— Continued

No on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
11.....	Red River near Gainesville.....	29,460	504 18,090 4,193	Jan 11-20, 1945 Apr. 1-3, 1945 Oct. 1944 to Sept. 1945	58	D	Records available: May 1, 1944 to Sept. 30, 1947
12.....	Sulphur River near Darden.....	2,754	23.7 28,750 2,225	Oct. 24, 27, 29, 1948 Jan. 28-29, 31, 1949 Oct. 1948 to Sept. 1949	64	D	Records available: Oct. 1, 1947 to Jan. 15, 1950
13.....	Salt Fork Brazos River near Aspermont....	4,834	.41 1,004 166	Apr. 1-5, 30, 1950 Sept. 6-10, 27-29, 1950 Oct. 1, 1949 to Sept. 30, 1950	40	D	Records available: Oct. 1, 1948 to Oct. 3, 1951
14.....	Double Mountain Fork Brazos River near Aspermont.	7,979	1.62 2,275 171	Feb. 1-13, 19-28, 1950 May 12-13, 1950 Oct. 1949 to Sept. 1950	40	D	Records available: Oct. 1, 1948 to Nov. 30, 1951
15.....	Clear Fork Brazos River near Nugent.....	2,220	4.15 860 58.1	Mar. 21-31, 1949 Sept. 15-16, 1949 Oct. 1, 1948 to Sept. 20, 1949	48	D	Records available: Aug. 20, 1948 to Sept. 30, 1953
16.....	Brazos River at Possum Kingdom Dam near Graford.	22,550	220	Oct. 1, 1952 to Sept. 30, 1953	12	D	Weighted average for 1953 water year. Records available: Jan. 15, 1942 to present
17.....	Daniel Salt Lake in Eastland County.....	.....	.....	June 8, 1950	1	Inf	Miscellaneous sample. Colony Creek drainage
18.....	Colony Creek in Eastland County.....	.....	.....	June 8, 1950 Sept. 11, 1950	4	Inf	Miscellaneous samples. Shows pollution by oil well brine
19.....	Rich Lake in Terry County.....	.....	.....	May 18, 1938	1	Inf	Represents saline lake on High Plains

20.....	Cedar Lake in Gaines County.....	.....	.....	Aug. 5, 1938	1	Inf	Represents saline lake on High Plains
21.....	Colorado River above Bull Creek near Knapp.	.....	.30 45.7	Apr. 12, 1950 July 21-29, 1950	29	D	No weighted average computed. Records available: Apr. 12, 1950 to Jan. 31, 1952
22.....	Colorado River at Colorado City.....	4,082	.0 1,091 86.6	Mar. 10, 20-31, Apr. 1-12, 1950 Sept. 6-9, 1950 Oct. 1949 to Sept. 1950	51	D	Records available: May 8, 1946 to present
23.....	Colorado River at Robert Lee.....	15,770	1.0 1,548 75.8	Apr. 1-10, 1951 June 3-4, 1951 Oct. 1950 to Sept. 1951	50	D	Records available: Oct. 1, 1947 to Sept. 30, 1951
24.....	Bull Creek near Ira.....	388	.36 110 30.3	Aug. 16-20, 1950 May 2, 1950 Apr. 12, 1950 to Sept. 30, 1950	28	D	Records available: Apr. 12, 1950 to Jan. 12, 1954
25	Bluff Creek near Ira.....	38	.....	Aug. 30, Sept. 1, 1950 May 1950	32	D	No weighted average computed. Records available: Apr. 12, 1950 to Sept. 30, 1950
26.....	Morgan Creek near Colorado City.....	.....	.05	Feb. 1-2, 6-8, 12, 1949 May 7-9, 1949	22	D	No weighted average computed. Records available: May 1, 1947 to July 31, 1949
27.....	Rio Grande at El Paso.....	29,267	740 86.2	July 1-30, 1951 Oct. 1-31, 1951	12	D	Records available: 1924 to present. Information from International Boundary and Water Commission, Water Bulletin 21, 1951
28.....	Rio Grande at Fort Quitman.....	31,990 including 1,384 in Mexico	8.0 128 (partly estimated	Apr. 1951 Aug. 1951	12	W	Do.
29.....	Rio Grande at the upper Presidio Station.	35,000 including 2,773 in Mexico	1.5 (estimated) 27.6	Mar. 1951 Aug. 1951	12	W	Do.

Table 4.—*Records and stream data of saline surface water in Texas*—Continued

No. on plate 9	Source	Drainage area (square miles)	Water discharge (cubic feet per second)	Date	Number of analyses	Frequency of sampling	Remarks
30.....	Red Bluff Lake on Pecos River in Loving and Reeves Counties.	.....	.....	Mar. 19, 1953	3	Inf	Miscellaneous sample
31.....	Pecos River near Orla.....	21,300	19.6 82.8 152	Sept. 1-30, 1951 Oct. 1-4, 1950 Oct. 1950 to Sept. 1951	15	D	Records available: July 1, 1937 to present
32.....	Lake Balmorhea on Toyah Creek in Reeves County.	.....	.....	Jan. 28, 1950	1	Inf	Miscellaneous sample
33.....	Toyah Creek below Toyah Lake near Pecos.	3,709	.1 15	Sept. 1-8, 1947 July 31, Aug. 1, 1948		D	Records available: Sept. 1939 to Oct. 1940 Oct. 1, 1943 to Sept. 30, 1944 Oct. 9, 1946 to Sept 1, 1950
34.....	Pecos River below Grandfalls.....	27,820	28.0 28.4 25.1	Dec. 1-31, 1949 Oct. 1-31, 1949 Oct. 1949 to Sept. 1950	12	D	Records available: Apr. 1, 1939 to June 30, 1942 Oct. 11, 1946 to present
35.....	Old River near Cove.....	.....	.....		16		Represents a normally fresh water stream affected by intrusion of Gulf water.
				Aug. 22-23, 27-28, 30, 1948		Inf	Aug. 23, 1946 to Oct. 16, 1946 Aug. 24, 1947 to Oct. 1, 1947
				Mar. 11-20, 1950		D	June 1, 1948 to Oct. 20, 1948 June 1, 1949 to present
36.....	Trinity River at Anahuac.....	.....	.....				Represents a normally fresh water stream affected by intrusion of Gulf water.
				Mar. 1-10, 1950		Inf	Aug. 22, 1946 to Sept. 22, 1946 Aug. 2, 1947 to Sept. 15, 1947 June 1948 to Sept. 30, 1948
				Oct. 21-31, 1952		D	June 1, 1949 to present
37.....	Laguna Madre at Carolina Beach pier.....	.....	.....	May 11, 1942	30	Inf	Special study

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APPENDIX

VII-5 Injection Test Reports - TRRC - Johnson County

FESCO, Ltd.
Petroleum Engineers

CORPORATE HEADQUARTERS: 1000 FESCO AVE. • ALICE, TEXAS 78332-7318 • (361) 661-7000

May 18, 2015

Mr. Steven Nations
Pinnergy, Ltd.
1167 Hills Lake Rd
Carthage, Texas 75633

Re:	Well:	Hwy 67 SWD 1
	Field:	Newark East (Barnett Shale)
	Location:	Johnson County, TX
	Prod Interval:	9341 – 11878 ft
	Formation:	Barnett Shale
	Test Date:	May 12 – 15, 2015

Dear Mr. Nations:

FESCO, Ltd. performed the following test procedure on the subject well:

1. Well Status = Shut in.
2. MIRU slickline trailer unit.
3. RIH with 1.25" weight bar and tagged an obstruction at 11659 ft. POOH.
4. RIH with tandem electronic memory gauges making static gradient stops.
5. Suspended gauges at 9300 ft for the duration of the test.
6. Conducted a 36 hr Reservoir Pressure Injection Test by pumping disposal water into the formation.
7. Conducted a 24 hr Reservoir Pressure Falloff Test by stopping the pumps and shutting in the well at the wing valve.
8. POOH with tandem electronic memory gauges making static gradient stops to surface.
9. Secured wellhead and well site.
10. RDMO.

The attached report contains the data collected during the above test procedure.

Injection Test: The injecting reservoir pressure "broke over" 7.65 hours after the injection period began and remained essentially stable at slightly above 4900 psia for the remainder of the 36 hour injection period (see Cartesian Plot). The reservoir and surface injection pressures recorded at the end of the 36 hour injection test were 4911.25 psia and 650 psig, respectively. The calculated overall injection fluid density (pressure gradient) between surface and 9300 ft is as follows:

Fluid Density = [4911.25 – (650 + 15)] / 9300
Fluid Density = 4246.25 / 9300
Fluid Density = 0.4566 psi/ft

Minimal wellbore storage activity occurred before 0.07 Delta Time (DT) hours. The zero-sloped (horizontal) pressure derivative data on the "Log Plot (Injection Test)" between 0.07 and 0.80 Delta Time hours indicates that a

linear pressure/time relationship exists during this interval on the "Semilog Plot (Injection Test)". The linear semilog data may represent radial flow from which reservoir properties (permeability to water, skin factor, etc.) could be uniquely determined via conventional semilog analysis. The data between 0.8 and 7.65 Delta Time hours have a 0.5-slope trend on the log plot and may indicate the presence of linear flow. The data after 7.65 Delta Time hours was not interpretable since most injection pressures during this period were decreasing.

Falloff Test: The reservoir pressure during the falloff test decreased until about 6.5 hours into the test. The reservoir pressure between 6.5 and 9.0 hours was essentially stable. The reservoir pressure during the remainder of the falloff test increased. The "Log Plot (Falloff Test)" chart indicates that wellbore storage occurred before 3 DT hours as evidenced by the unit-sloped pressure derivative data. Transition from wellbore storage to a reservoir flow regime occurred between 3 and 6 DT hours. However, the remainder of the test was not interpretable because of the increasing falloff pressures that continued until the test ended. Since the late-time data does not exhibit a radial flow or boundary flow regime, it is not valid to extrapolate the late-time data to infinite shut-in time to obtain an estimated P* value. However, the late-time pressure extrapolation to infinite shut-in time of 4822.97 psia was included on the Horner Plot for completeness. The minimum recorded falloff pressure (4813.48 psia) occurred 8.58 hours after the falloff test started.

Static Gradient Surveys: FESCO conducted a static gradient survey at the beginning (5/12/2015) and end (5/15/2015) of the test procedure. Both surveys indicate a water level at surface. The reservoir fluid density at 9300 ft on 5/12/2015 and 5/15/2015 was 0.4657 psi/ft and 0.4582 psi/ft, respectively. These values compare well with the value (0.4566 psi/ft) calculated at maximum reservoir and surface pressure during the injection test (see Injection Test discussion above).

FESCO, Ltd. appreciates the opportunity to work for Pinnergy, Ltd. Please call me if you have any questions concerning this report.

Thank you,

FESCO, Ltd.

Edwin P. Bickham, P.E.
Vice President
FESCO, Ltd.
361-661-7000 Ext. 115
Ed.Bickham@FescoInc.com

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

STATIC GRADIENT SURVEY

Company:	Pinnergy, Ltd.	Test Date:	5/12/2015
Well:	Highway 67 SWD 1	Location:	Johnson County, TX
Field:	Newark East (Barnett Shale)	Status:	Shut in.
Formation:	Barnett Shale		

Well Data:	Wellhead Connection: 3" Regular	Gauge Type:	Electronic
	Elevation: 14 ft above GL	Gauge SN:	SP-79244R
	Tubing: 4" Set at 9283 ft (Packer)	Gauge Range:	15000 psi
	Casing: 7" Set at 9341 ft	Gauge OD:	1.2500"
	Perfs: 9341 - 11878 ft (MD)		
	Datum: 10610 ft (MD)		

Depth			Pressure					
MD ft	TVD ft	Delta Depth ft	WHP psig	BHT °F	Gauge Pressure psig	Delta Pressure psi	Pressure Gradient psi / ft	Comments
0	0	0	422	65.01	424.13	0.00	0.0000	RIH making static gradient stops.
3000	3000	3000		99.18	1835.01	1410.88	0.4703	
6000	6000	3000		134.37	3249.58	1414.57	0.4715	
8000	8000	2000		152.21	4189.05	939.47	0.4697	
8500	8500	500		158.01	4425.18	236.13	0.4723	
9000	9000	500		172.89	4656.50	231.32	0.4626	
9300	9300	300	422	171.38	4796.22	139.72	0.4657	Start injection pumps at 2.5 BPM..

BHT at Test Depth:	171.4 °F	Oil Level:	None	Previous BHP:	U/A
Extrapolated BHP at Datum:	5406.29 psig	Water Level:	Surface	BHP Change:	U/A
BHP Gradient at Datum :	0.4657 psi/ft	Csg Press:	N/A		

Remarks: MIRU slickline. RIH with 1.25" wt bar. Tagged at 11659 ft. POOH. RIH with tandem EMP making static gradient stops to 9300 ft. Suspended EMP on slickline. Conducted 36 hr injection test and 24 hr falloff test. POOH making static gradient stops. RDMO.

Certified: FESCO, Ltd. - Alice, Texas

Job No.: J201505130901.001A

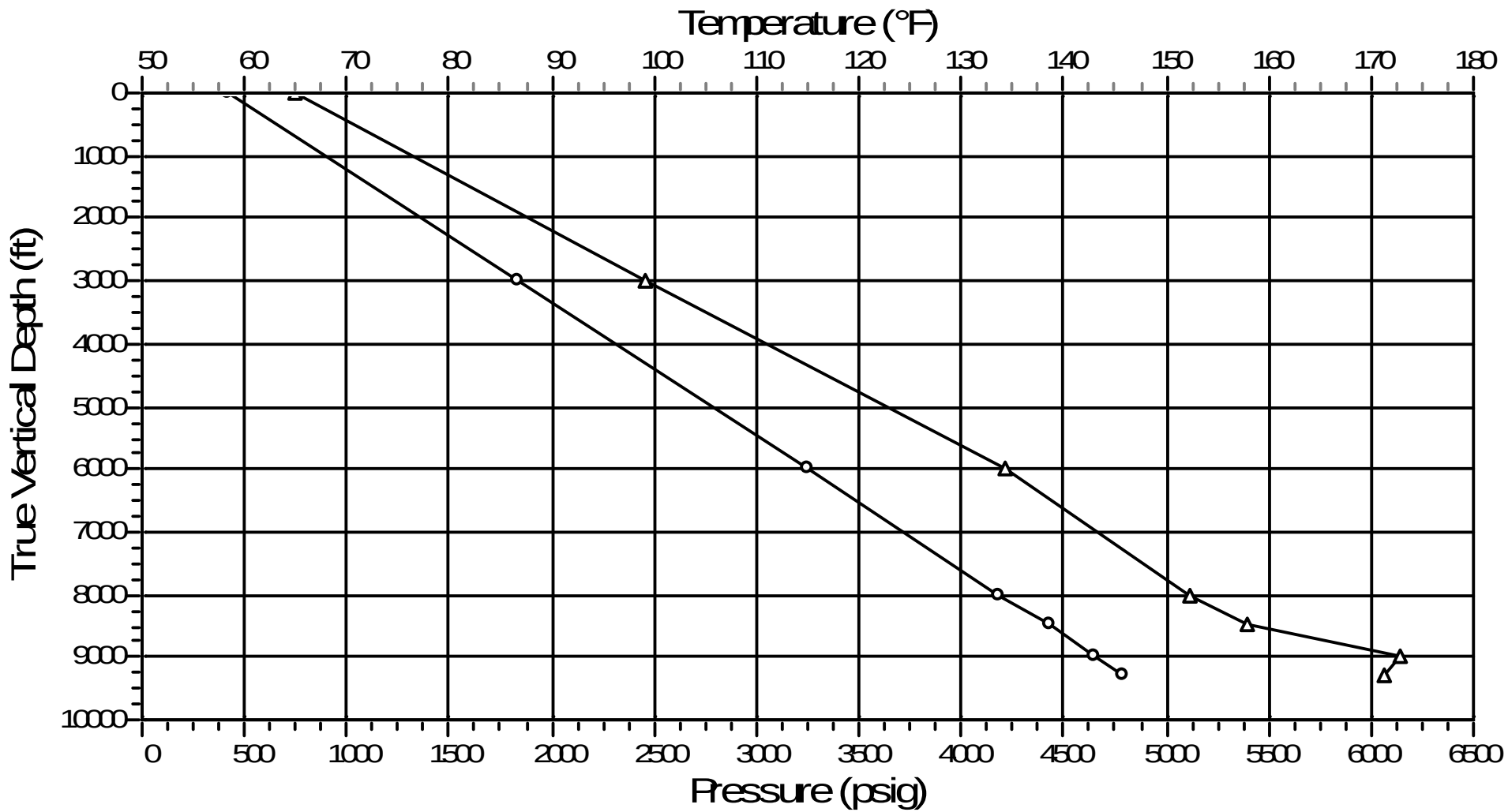
By: _____

Edwin P. Bickham, P.E.
Vice-President - (361) 661-7000 Ext. 115

Pinnergy, Ltd.

Static Gradient Plot

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/12/2015	Gauge SN:	SP-79244R



J20150513090 1.001A

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	08:44:05	-37.86583		17.98		65.55	Powered up gauge.
05/12/15	08:45:00	-37.85056		17.75		65.54	
05/12/15	08:50:10	-37.76444		17.62		65.60	
05/12/15	08:51:10	-37.74778		17.60		65.57	
05/12/15	08:52:10	-37.73111		397.95		65.71	Pressured up lubricator.
05/12/15	08:54:10	-37.69778		422.52		65.49	
05/12/15	08:56:10	-37.66444		423.75		65.35	
05/12/15	08:58:10	-37.63111		423.60		65.26	
05/12/15	09:00:10	-37.59778		423.74		65.18	
05/12/15	09:02:10	-37.56444		423.62		65.11	
05/12/15	09:04:10	-37.53111		423.56		65.06	
05/12/15	09:06:00	-37.50056		423.60		65.02	Csg Press = 0 psig.
05/12/15	09:06:10	-37.49778	422	424.13		65.01	RIH making static gradient stops.
05/12/15	09:07:10	-37.48111		480.60		69.88	
05/12/15	09:08:10	-37.46444		574.51		72.79	
05/12/15	09:09:10	-37.44778		718.90		75.97	
05/12/15	09:10:10	-37.43111		877.46		79.03	
05/12/15	09:11:10	-37.41444		1037.68		81.65	
05/12/15	09:12:10	-37.39778		1166.56		84.56	
05/12/15	09:13:10	-37.38111		1322.60		87.29	
05/12/15	09:14:10	-37.36444		1475.04		90.17	
05/12/15	09:15:10	-37.34778		1614.21		93.35	
05/12/15	09:16:10	-37.33111		1754.38		96.55	
05/12/15	09:16:50	-37.32000		1835.23		98.37	Arrived at 3000 ft stop.
05/12/15	09:17:10	-37.31444		1835.14		98.92	
05/12/15	09:18:10	-37.29778		1835.17		99.07	
05/12/15	09:19:10	-37.28111		1835.14		99.05	
05/12/15	09:20:10	-37.26444		1835.11		99.07	
05/12/15	09:21:10	-37.24778		1834.91		99.12	
05/12/15	09:22:10	-37.23111		1835.01		99.18	Left 3000 ft stop.
05/12/15	09:23:10	-37.21444		1956.47		100.82	
05/12/15	09:24:10	-37.19778		2085.80		104.00	
05/12/15	09:25:10	-37.18111		2220.69		106.72	
05/12/15	09:26:10	-37.16444		2359.95		109.75	
05/12/15	09:27:10	-37.14778		2500.16		112.80	
05/12/15	09:28:10	-37.13111		2644.28		117.85	
05/12/15	09:29:10	-37.11444		2784.63		121.14	
05/12/15	09:30:10	-37.09778		2919.06		125.18	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	09:31:10	-37.08111		3042.03		127.10	
05/12/15	09:32:10	-37.06444		3171.99		128.81	
05/12/15	09:32:50	-37.05333		3250.01		131.46	Arrived at 6000 ft stop.
05/12/15	09:33:10	-37.04778		3249.75		132.90	
05/12/15	09:34:10	-37.03111		3249.83		133.67	
05/12/15	09:35:10	-37.01444		3249.80		133.93	
05/12/15	09:36:10	-36.99778		3249.76		134.12	
05/12/15	09:37:10	-36.98111		3249.54		134.25	
05/12/15	09:38:10	-36.96444		3249.59		134.36	
05/12/15	09:38:20	-36.96167		3249.58		134.37	Left 6000 ft stop.
05/12/15	09:39:10	-36.94778		3328.71		135.36	
05/12/15	09:40:10	-36.93111		3441.51		136.38	
05/12/15	09:41:10	-36.91444		3557.96		138.86	
05/12/15	09:42:10	-36.89778		3678.44		142.03	
05/12/15	09:43:10	-36.88111		3800.46		145.18	
05/12/15	09:44:10	-36.86444		3924.49		145.67	
05/12/15	09:45:10	-36.84778		4048.06		150.95	
05/12/15	09:46:10	-36.83111		4173.30		152.58	
05/12/15	09:46:20	-36.82833		4189.09		152.74	Arrived at 8000 ft stop.
05/12/15	09:47:10	-36.81444		4188.74		152.47	
05/12/15	09:48:10	-36.79778		4188.80		152.37	
05/12/15	09:49:10	-36.78111		4189.05		152.28	
05/12/15	09:50:10	-36.76444		4188.97		152.22	
05/12/15	09:51:10	-36.74778		4188.96		152.21	
05/12/15	09:51:50	-36.73667		4189.05		152.21	Left 8000 ft stop.
05/12/15	09:52:10	-36.73111		4215.69		152.33	
05/12/15	09:53:10	-36.71444		4319.59		154.53	
05/12/15	09:54:10	-36.69778		4421.26		156.30	Arrived at 8500 ft stop.
05/12/15	09:55:10	-36.68111		4423.23		157.54	
05/12/15	09:56:10	-36.66444		4423.33		157.74	
05/12/15	09:57:10	-36.64778		4423.40		157.86	
05/12/15	09:58:10	-36.63111		4423.24		157.93	
05/12/15	09:59:10	-36.61444		4423.46		157.99	
05/12/15	09:59:40	-36.60611		4425.18		158.01	Left 8500 ft stop.
05/12/15	10:00:10	-36.59778		4471.25		158.83	
05/12/15	10:01:10	-36.58111		4572.72		161.91	
05/12/15	10:02:00	-36.56722		4657.30		167.37	Arrived at 9000 ft stop.
05/12/15	10:02:10	-36.56444		4657.24		169.04	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	10:03:10	-36.54778		4656.55		171.40	
05/12/15	10:04:10	-36.53111		4656.49		172.12	
05/12/15	10:05:10	-36.51444		4656.52		172.53	
05/12/15	10:06:10	-36.49778		4656.55		172.73	
05/12/15	10:07:10	-36.48111		4656.67		172.87	
05/12/15	10:07:20	-36.47833		4656.50		172.89	Left 9000 ft stop.
05/12/15	10:08:10	-36.46444		4740.40		173.91	
05/12/15	10:08:50	-36.45333	422	4796.35		173.89	Gauge at TD=9300 ft.
05/12/15	10:09:10	-36.44778		4796.32		173.02	
05/12/15	10:10:10	-36.43111		4796.48		171.95	
05/12/15	10:11:10	-36.41444		4796.25		171.49	
05/12/15	10:12:10	-36.39778		4796.24		171.41	
05/12/15	10:13:00	-36.38389	422	4795.94		171.38	
05/12/15	10:13:10	-36.38111		4796.07		171.38	
05/12/15	10:14:10	-36.36444		4795.97		171.36	
05/12/15	10:15:10	-36.34778		4796.06		171.35	
05/12/15	10:16:10	-36.33111		4795.93		171.34	
05/12/15	10:17:10	-36.31444		4796.05		171.34	
05/12/15	10:18:10	-36.29778		4796.30		171.34	
05/12/15	10:19:10	-36.28111		4796.27		171.33	
05/12/15	10:20:10	-36.26444		4796.12		171.33	
05/12/15	10:21:10	-36.24778		4796.19		171.34	
05/12/15	10:22:10	-36.23111		4796.24		171.34	
05/12/15	10:23:10	-36.21444		4796.24		171.35	
05/12/15	10:24:10	-36.19778		4796.23		171.35	
05/12/15	10:25:10	-36.18111		4796.15		171.36	
05/12/15	10:26:10	-36.16444		4796.00		171.36	
05/12/15	10:27:10	-36.14778		4796.24		171.37	
05/12/15	10:28:10	-36.13111		4796.22		171.37	
05/12/15	10:29:10	-36.11444		4796.48		171.37	
05/12/15	10:30:10	-36.09778		4796.15		171.38	
05/12/15	10:31:10	-36.08111		4796.30		171.39	
05/12/15	10:32:10	-36.06444		4796.19		171.39	
05/12/15	10:33:10	-36.04778		4796.13		171.39	
05/12/15	10:33:20	-36.04500	422	4796.22		171.38	Start injection pumps at 2.5 BPM..
05/12/15	10:33:30	-36.04222		4839.15		171.41	
05/12/15	10:33:40	-36.03944		4813.02		171.46	
05/12/15	10:33:50	-36.03667		4808.39		172.33	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	10:34:00	-36.03389		4816.44		173.53	
05/12/15	10:34:10	-36.03111		4805.00		173.64	
05/12/15	10:34:20	-36.02833		4807.65		173.39	
05/12/15	10:34:30	-36.02556		4812.62		173.32	
05/12/15	10:34:40	-36.02278		4800.25		173.14	
05/12/15	10:34:50	-36.02000		4810.33		172.78	
05/12/15	10:35:00	-36.01722		4815.48		172.72	
05/12/15	10:35:10	-36.01444		4811.38		173.21	
05/12/15	10:35:20	-36.01167		4802.24		173.55	
05/12/15	10:35:30	-36.00889		4816.49		173.92	
05/12/15	10:35:40	-36.00611		4805.94		174.27	
05/12/15	10:35:50	-36.00333		4815.06		174.20	
05/12/15	10:36:00	-36.00056		4814.92		173.56	
05/12/15	10:36:10	-35.99778		4820.99		172.51	
05/12/15	10:36:20	-35.99500		4816.49		171.39	
05/12/15	10:36:30	-35.99222		4821.28		170.68	
05/12/15	10:36:40	-35.98944		4813.64		170.33	
05/12/15	10:36:50	-35.98667		4818.93		170.06	
05/12/15	10:37:00	-35.98389		4813.52		169.56	
05/12/15	10:37:10	-35.98111		4822.71		168.84	
05/12/15	10:37:20	-35.97833		4823.00		168.16	
05/12/15	10:37:30	-35.97556		4823.50		167.55	
05/12/15	10:37:40	-35.97278		4823.69		166.91	
05/12/15	10:37:50	-35.97000		4824.58		166.30	
05/12/15	10:38:00	-35.96722		4824.87		165.77	
05/12/15	10:38:10	-35.96444		4825.30		165.27	
05/12/15	10:38:20	-35.96167		4825.69		164.84	
05/12/15	10:38:30	-35.95889		4826.28		164.49	
05/12/15	10:38:50	-35.95333		4827.06		163.74	
05/12/15	10:39:00	-35.95056		4827.38		163.35	
05/12/15	10:39:10	-35.94778		4827.58		162.98	
05/12/15	10:39:30	-35.94222		4828.40		162.22	
05/12/15	10:39:40	-35.93944		4828.90		161.92	
05/12/15	10:39:50	-35.93667		4829.41		161.66	
05/12/15	10:40:10	-35.93111		4829.73		161.16	
05/12/15	10:40:30	-35.92556		4829.83		160.78	
05/12/15	10:40:40	-35.92278		4830.70		160.61	
05/12/15	10:41:00	-35.91722		4830.83		160.26	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	10:41:20	-35.91167		4831.62		159.88	
05/12/15	10:41:30	-35.90889		4831.80		159.68	
05/12/15	10:41:50	-35.90333		4832.33		159.37	
05/12/15	10:42:10	-35.89778		4832.53		159.09	
05/12/15	10:42:30	-35.89222		4833.00		158.86	
05/12/15	10:43:00	-35.88389		4833.73		158.68	
05/12/15	10:43:20	-35.87833		4834.18		158.51	
05/12/15	10:43:40	-35.87278		4834.34		158.33	
05/12/15	10:44:10	-35.86444		4835.16		157.95	
05/12/15	10:44:30	-35.85889		4835.71		157.58	
05/12/15	10:45:00	-35.85056		4836.05		156.94	
05/12/15	10:45:20	-35.84500		4836.10		156.64	
05/12/15	10:45:50	-35.83667		4836.80		156.30	
05/12/15	10:46:20	-35.82833		4837.49		155.94	
05/12/15	10:46:50	-35.82000		4837.71		155.66	
05/12/15	10:47:20	-35.81167		4838.20		155.36	
05/12/15	10:48:00	-35.80056		4838.47		154.92	
05/12/15	10:48:30	-35.79222		4839.24		154.61	
05/12/15	10:49:10	-35.78111		4839.85		154.19	
05/12/15	10:49:40	-35.77278		4840.33		153.87	
05/12/15	10:50:20	-35.76167		4840.38		153.44	
05/12/15	10:51:00	-35.75056		4841.01		153.05	
05/12/15	10:51:40	-35.73944		4841.40		152.69	
05/12/15	10:52:20	-35.72833		4842.02		152.35	
05/12/15	10:53:10	-35.71444		4842.59		151.91	
05/12/15	10:54:00	-35.70056		4843.00		151.43	
05/12/15	10:54:40	-35.68944		4843.39		151.06	
05/12/15	10:55:30	-35.67556		4843.58		150.63	
05/12/15	10:56:30	-35.65889		4844.35		150.14	
05/12/15	10:57:20	-35.64500		4844.70		149.74	
05/12/15	10:58:20	-35.62833		4845.16		149.27	
05/12/15	10:59:10	-35.61444		4845.63		148.88	
05/12/15	11:00:20	-35.59500		4846.30		148.34	
05/12/15	11:01:20	-35.57833		4846.79		147.88	
05/12/15	11:02:20	-35.56167		4846.79		147.41	
05/12/15	11:03:30	-35.54222		4847.72		146.88	
05/12/15	11:04:40	-35.52278		4848.31		146.36	
05/12/15	11:06:00	-35.50056		4848.78		145.77	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	11:07:10	-35.48111		4849.35		145.27	
05/12/15	11:08:30	-35.45889		4849.79		144.70	
05/12/15	11:09:50	-35.43667		4850.10		144.13	
05/12/15	11:11:20	-35.41167		4850.35		143.51	
05/12/15	11:12:50	-35.38667		4851.23		142.89	
05/12/15	11:14:20	-35.36167		4851.65		142.29	
05/12/15	11:16:00	-35.33389		4852.08		141.63	
05/12/15	11:17:40	-35.30611		4852.08		140.96	
05/12/15	11:19:20	-35.27833		4852.70		140.31	
05/12/15	11:21:10	-35.24778		4853.26		139.61	
05/12/15	11:23:00	-35.21722		4853.77		138.91	
05/12/15	11:25:00	-35.18389		4854.45		138.16	
05/12/15	11:27:00	-35.15056		4854.84		137.42	
05/12/15	11:29:00	-35.11722		4855.53		136.68	
05/12/15	11:31:10	-35.08111		4856.14		135.90	
05/12/15	11:33:30	-35.04222		4856.67		135.08	
05/12/15	11:35:50	-35.00333		4857.46		134.28	
05/12/15	11:38:20	-34.96167		4857.63		133.44	
05/12/15	11:40:50	-34.92000		4858.65		132.62	
05/12/15	11:43:30	-34.87556		4859.38		131.76	
05/12/15	11:46:10	-34.83111		4860.18		130.92	
05/12/15	11:49:00	-34.78389		4860.81		130.08	
05/12/15	11:52:00	-34.73389		4861.66		129.18	
05/12/15	11:55:10	-34.68111		4862.32		128.29	
05/12/15	11:58:20	-34.62833		4862.95		127.42	
05/12/15	12:01:40	-34.57278		4863.48		126.53	
05/12/15	12:05:00	-34.51722		4864.09		125.68	
05/12/15	12:08:40	-34.45611		4864.90		124.77	
05/12/15	12:12:20	-34.39500		4865.40		123.89	
05/12/15	12:16:10	-34.33111		4866.50		123.02	
05/12/15	12:20:20	-34.26167		4867.09		122.12	
05/12/15	12:24:30	-34.19222		4868.25		121.25	
05/12/15	12:28:50	-34.12000		4868.85		120.41	
05/12/15	12:33:20	-34.04500		4869.85		119.57	
05/12/15	12:38:00	-33.96722		4870.64		118.76	
05/12/15	12:42:50	-33.88667		4871.49		117.95	
05/12/15	12:48:00	-33.80056		4871.97		117.14	
05/12/15	12:53:10	-33.71444		4872.41		116.38	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	12:58:40	-33.62278		4873.58		115.62	
05/12/15	13:04:20	-33.52833		4874.06		114.91	
05/12/15	13:10:20	-33.42833		4874.76		114.18	
05/12/15	13:16:20	-33.32833		4875.49		113.51	
05/12/15	13:22:50	-33.22000		4876.84		112.84	
05/12/15	13:29:20	-33.11167		4877.32		112.21	
05/12/15	13:36:20	-32.99500		4878.63		111.59	
05/12/15	13:43:30	-32.87556		4879.41		110.99	
05/12/15	13:50:50	-32.75333		4881.24		110.43	
05/12/15	13:58:40	-32.62278		4881.73		109.86	
05/12/15	14:06:40	-32.48944		4883.55		109.33	
05/12/15	14:15:00	-32.35056		4884.38		108.81	
05/12/15	14:23:40	-32.20611		4886.04		108.32	
05/12/15	14:32:40	-32.05611		4886.44		107.85	
05/12/15	14:42:00	-31.90056		4888.61		107.37	
05/12/15	14:51:50	-31.73667		4889.85		106.16	
05/12/15	15:01:50	-31.57000		4891.50		105.36	
05/12/15	15:12:20	-31.39500		4893.10		104.69	
05/12/15	15:23:20	-31.21167		4894.25		104.09	
05/12/15	15:34:40	-31.02278		4895.88		103.55	
05/12/15	15:46:30	-30.82556		4897.56		103.05	
05/12/15	15:58:40	-30.62278		4899.62		102.60	
05/12/15	16:11:20	-30.41167		4901.42		102.17	
05/12/15	16:24:40	-30.18944		4902.20		101.75	
05/12/15	16:38:20	-29.96167		4903.67		101.38	
05/12/15	16:52:40	-29.72278		4904.96		101.03	
05/12/15	17:07:30	-29.47556		4906.53		100.70	
05/12/15	17:22:50	-29.22000		4907.72		100.37	
05/12/15	17:39:00	-28.95056		4909.26		100.06	
05/12/15	17:55:40	-28.67278		4910.64		99.77	
05/12/15	18:12:50	-28.38667		4912.09		99.48	
05/12/15	18:30:50	-28.08667		4912.31		99.20	
05/12/15	18:49:30	-27.77556		4912.53		98.92	
05/12/15	19:09:00	-27.45056		4912.32		98.65	
05/12/15	19:29:10	-27.11444		4912.20		98.39	
05/12/15	19:50:10	-26.76444		4911.75		98.12	
05/12/15	20:11:50	-26.40333		4911.32		97.87	
05/12/15	20:34:30	-26.02556		4910.80		97.63	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/12/15	20:58:00	-25.63389		4911.10		97.39	
05/12/15	21:22:30	-25.22556		4911.20		97.17	
05/12/15	21:47:50	-24.80333		4911.18		96.93	
05/12/15	22:14:20	-24.36167		4911.20		96.71	
05/12/15	22:41:40	-23.90611		4911.32		96.49	
05/12/15	23:10:10	-23.43111		4911.79		96.28	
05/12/15	23:39:50	-22.93667		4911.16		96.07	
05/13/15	00:10:30	-22.42556		4910.78		95.88	
05/13/15	00:42:30	-21.89222		4910.38		95.69	
05/13/15	01:15:50	-21.33667		4910.58		95.49	
05/13/15	01:50:20	-20.76167		4910.40		95.30	
05/13/15	02:26:10	-20.16444		4909.92		95.12	
05/13/15	03:03:30	-19.54222		4909.23		94.95	
05/13/15	03:42:10	-18.89778		4906.91		94.78	
05/13/15	04:22:30	-18.22556		4905.80		94.64	
05/13/15	05:04:20	-17.52833		4905.05		94.52	
05/13/15	05:47:50	-16.80333		4905.12		94.41	
05/13/15	06:33:00	-16.05056		4904.32		94.33	
05/13/15	07:19:50	-15.27000		4903.87		94.26	
05/13/15	08:08:40	-14.45611		4904.12		94.19	
05/13/15	08:59:20	-13.61167		4903.82		94.11	
05/13/15	09:52:00	-12.73389		4903.03		94.00	
05/13/15	10:46:40	-11.82278		4902.98		93.85	
05/13/15	11:43:40	-10.87278		4903.08		93.68	
05/13/15	12:42:40	-9.88944		4902.13		93.53	
05/13/15	13:44:10	-8.86444		4902.42		93.44	
05/13/15	14:47:50	-7.80333		4903.29		93.37	
05/13/15	15:54:10	-6.69778		4904.69		93.32	
05/13/15	17:03:10	-5.54778		4906.32		93.22	
05/13/15	18:14:40	-4.35611		4908.31		93.11	
05/13/15	19:29:10	-3.11444		4908.20		92.98	
05/13/15	20:46:20	-1.82833		4908.28		92.86	
05/13/15	22:06:40	-0.48944		4910.11		92.76	
05/13/15	22:35:00	-0.01722		4911.19		92.71	Pump Rate = 2.5 BPM.
05/13/15	22:35:02	-0.01667	665	4911.25		92.72	Turned off pumps.
05/13/15	22:35:06	-0.01556		4908.47		92.72	Shut in well for falloff test.
05/13/15	22:35:10	-0.01444		4908.88		92.71	L
05/13/15	22:35:32	-0.00833		4904.27		92.80	L

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/13/15	22:36:02	0.00000		4904.52	0.00	92.99	L-Start SI
05/13/15	22:36:14	0.00333		4904.34	-0.18	93.05	L
05/13/15	22:36:40	0.01056		4904.41	-0.11	93.17	L
05/13/15	22:37:02	0.01667		4904.05	-0.47	93.26	
05/13/15	22:37:06	0.01778		4904.17	-0.35	93.27	
05/13/15	22:37:10	0.01889		4904.16	-0.36	93.28	
05/13/15	22:37:32	0.02500		4904.12	-0.40	93.33	
05/13/15	22:37:38	0.02667		4903.45	-1.07	93.35	
05/13/15	22:37:44	0.02833		4903.79	-0.73	93.36	
05/13/15	22:37:56	0.03167		4903.48	-1.04	93.38	
05/13/15	22:38:10	0.03556		4903.23	-1.29	93.41	
05/13/15	22:38:18	0.03778		4903.23	-1.29	93.44	
05/13/15	22:38:26	0.04000		4903.41	-1.11	93.46	
05/13/15	22:38:34	0.04222		4903.36	-1.16	93.49	
05/13/15	22:38:42	0.04444		4903.12	-1.40	93.51	
05/13/15	22:38:50	0.04667		4902.98	-1.54	93.54	
05/13/15	22:39:00	0.04944		4902.94	-1.58	93.58	
05/13/15	22:39:08	0.05167		4902.85	-1.67	93.62	
05/13/15	22:39:18	0.05444		4902.70	-1.82	93.67	
05/13/15	22:39:28	0.05722		4902.44	-2.08	93.72	
05/13/15	22:39:38	0.06000		4902.35	-2.17	93.77	
05/13/15	22:39:50	0.06333		4902.41	-2.11	93.83	
05/13/15	22:40:00	0.06611		4902.12	-2.40	93.89	
05/13/15	22:40:12	0.06944		4902.10	-2.42	93.98	
05/13/15	22:40:24	0.07278		4902.10	-2.42	94.06	
05/13/15	22:40:36	0.07611		4901.83	-2.69	94.15	
05/13/15	22:40:50	0.08000		4901.81	-2.71	94.25	
05/13/15	22:41:04	0.08389		4901.43	-3.09	94.35	
05/13/15	22:41:18	0.08778		4901.33	-3.19	94.46	
05/13/15	22:41:32	0.09167		4901.32	-3.20	94.58	
05/13/15	22:41:48	0.09611		4900.98	-3.54	94.71	
05/13/15	22:42:04	0.10056		4900.88	-3.64	94.86	
05/13/15	22:42:20	0.10500		4900.76	-3.76	94.99	
05/13/15	22:42:36	0.10944		4900.70	-3.82	95.14	
05/13/15	22:42:54	0.11444		4900.34	-4.18	95.31	
05/13/15	22:43:14	0.12000		4900.13	-4.39	95.50	
05/13/15	22:43:32	0.12500		4899.91	-4.61	95.67	
05/13/15	22:43:52	0.13056		4900.06	-4.46	95.86	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/13/15	22:44:12	0.13611		4899.53	-4.99	96.06	
05/13/15	22:44:34	0.14222		4899.55	-4.97	96.28	
05/13/15	22:44:56	0.14833		4899.25	-5.27	96.50	
05/13/15	22:45:20	0.15500		4899.30	-5.22	96.74	
05/13/15	22:45:44	0.16167		4898.70	-5.82	97.00	
05/13/15	22:46:10	0.16889		4898.74	-5.78	97.26	
05/13/15	22:46:36	0.17611		4898.33	-6.19	97.52	
05/13/15	22:47:02	0.18333		4898.12	-6.40	97.79	
05/13/15	22:47:30	0.19111		4897.95	-6.57	98.06	
05/13/15	22:48:00	0.19944		4897.58	-6.94	98.38	
05/13/15	22:48:30	0.20778		4897.43	-7.09	98.68	
05/13/15	22:49:02	0.21667		4897.21	-7.31	99.01	
05/13/15	22:49:34	0.22556		4896.85	-7.67	99.32	
05/13/15	22:50:08	0.23500		4896.39	-8.13	99.66	
05/13/15	22:50:44	0.24500		4896.27	-8.25	100.00	
05/13/15	22:51:20	0.25500		4895.98	-8.54	100.34	
05/13/15	22:52:00	0.26611		4895.60	-8.92	100.72	
05/13/15	22:52:38	0.27667		4895.40	-9.12	101.06	
05/13/15	22:53:20	0.28833		4894.95	-9.57	101.42	
05/13/15	22:54:04	0.30056		4894.58	-9.94	101.80	
05/13/15	22:54:48	0.31278		4894.38	-10.14	102.17	
05/13/15	22:55:34	0.32556		4894.06	-10.46	102.55	
05/13/15	22:56:22	0.33889		4893.83	-10.69	102.93	
05/13/15	22:57:12	0.35278		4893.57	-10.95	103.32	
05/13/15	22:58:04	0.36722		4892.77	-11.75	103.71	
05/13/15	22:58:58	0.38222		4892.62	-11.90	104.12	
05/13/15	22:59:54	0.39778		4892.20	-12.32	104.52	
05/13/15	23:00:54	0.41444		4891.78	-12.74	104.94	
05/13/15	23:01:54	0.43111		4891.39	-13.13	105.36	
05/13/15	23:02:56	0.44833		4890.90	-13.62	105.77	
05/13/15	23:04:02	0.46667		4890.36	-14.16	106.19	
05/13/15	23:05:10	0.48556		4890.00	-14.52	106.63	
05/13/15	23:06:22	0.50556		4889.50	-15.02	107.08	
05/13/15	23:07:34	0.52556		4889.06	-15.46	107.54	
05/13/15	23:08:50	0.54667		4888.59	-15.93	107.99	
05/13/15	23:10:10	0.56889		4888.12	-16.40	108.46	
05/13/15	23:11:32	0.59167		4887.36	-17.16	108.92	
05/13/15	23:12:58	0.61556		4886.89	-17.63	109.40	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/13/15	23:14:28	0.64056		4886.45	-18.07	109.89	
05/13/15	23:16:00	0.66611		4885.96	-18.56	110.38	
05/13/15	23:17:36	0.69278		4885.19	-19.33	110.88	
05/13/15	23:19:16	0.72056		4884.56	-19.96	111.38	
05/13/15	23:21:00	0.74944		4884.02	-20.50	111.91	
05/13/15	23:22:48	0.77944		4883.24	-21.28	112.43	
05/13/15	23:24:40	0.81056		4882.61	-21.91	112.95	
05/13/15	23:26:36	0.84278		4881.97	-22.55	113.49	
05/13/15	23:28:38	0.87667		4881.14	-23.38	114.04	
05/13/15	23:30:44	0.91167		4880.52	-24.00	114.60	
05/13/15	23:32:54	0.94778		4879.48	-25.04	115.16	
05/13/15	23:35:10	0.98556		4878.90	-25.62	115.73	
05/13/15	23:37:30	1.02444		4877.99	-26.53	116.31	
05/13/15	23:39:58	1.06556		4877.10	-27.42	116.91	
05/13/15	23:42:30	1.10778		4876.18	-28.34	117.51	
05/13/15	23:45:08	1.15167		4875.30	-29.22	118.12	
05/13/15	23:47:52	1.19722		4874.56	-29.96	118.73	
05/13/15	23:50:44	1.24500		4873.49	-31.03	119.36	
05/13/15	23:53:42	1.29444		4872.19	-32.33	120.00	
05/13/15	23:56:46	1.34556		4871.57	-32.95	120.62	
05/13/15	23:59:58	1.39889		4870.41	-34.11	121.27	
05/14/15	00:03:18	1.45444		4869.28	-35.24	121.92	
05/14/15	00:06:44	1.51167		4868.07	-36.45	122.58	
05/14/15	00:10:20	1.57167		4867.04	-37.48	123.26	
05/14/15	00:14:04	1.63389		4865.74	-38.78	123.94	
05/14/15	00:17:56	1.69833		4864.47	-40.05	124.62	
05/14/15	00:21:58	1.76556		4863.21	-41.31	125.31	
05/14/15	00:26:08	1.83500		4861.91	-42.61	126.01	
05/14/15	00:30:30	1.90778		4860.80	-43.72	126.72	
05/14/15	00:35:00	1.98278		4859.24	-45.28	127.41	
05/14/15	00:39:42	2.06111		4857.93	-46.59	128.13	
05/14/15	00:44:34	2.14222		4856.30	-48.22	128.85	
05/14/15	00:49:38	2.22667		4854.71	-49.81	129.58	
05/14/15	00:54:54	2.31444		4853.20	-51.32	130.30	
05/14/15	01:00:22	2.40556		4851.89	-52.63	131.01	
05/14/15	01:06:04	2.50056		4849.93	-54.59	131.75	
05/14/15	01:11:58	2.59889		4848.08	-56.44	132.47	
05/14/15	01:18:08	2.70167		4846.46	-58.06	133.19	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/14/15	01:24:30	2.80778		4844.81	-59.71	133.92	
05/14/15	01:31:08	2.91833		4842.87	-61.65	134.65	
05/14/15	01:38:02	3.03333		4840.99	-63.53	135.37	
05/14/15	01:45:10	3.15222		4839.16	-65.36	136.09	
05/14/15	01:52:38	3.27667		4837.12	-67.40	136.81	
05/14/15	02:00:20	3.40500		4835.20	-69.32	137.52	
05/14/15	02:08:25	3.53972		4833.46	-71.06	138.21	
05/14/15	02:16:45	3.67861		4831.78	-72.74	138.91	
05/14/15	02:25:25	3.82306		4829.73	-74.79	139.60	
05/14/15	02:34:25	3.97306		4827.80	-76.72	140.30	
05/14/15	02:43:50	4.13000		4826.03	-78.49	141.00	
05/14/15	02:53:35	4.29250		4824.42	-80.10	141.68	
05/14/15	03:03:40	4.46056		4822.86	-81.66	142.35	
05/14/15	03:14:10	4.63556		4821.57	-82.95	143.01	
05/14/15	03:25:05	4.81750		4820.04	-84.48	143.66	
05/14/15	03:36:25	5.00639		4818.79	-85.73	144.30	
05/14/15	03:48:15	5.20361		4817.81	-86.71	144.92	
05/14/15	04:00:30	5.40778		4816.94	-87.58	145.54	
05/14/15	04:13:15	5.62028		4816.13	-88.39	146.16	
05/14/15	04:26:25	5.83972		4815.29	-89.23	146.75	
05/14/15	04:40:10	6.06889		4814.89	-89.63	147.34	
05/14/15	04:54:30	6.30778		4814.44	-90.08	147.92	
05/14/15	05:09:20	6.55500		4814.05	-90.47	148.50	
05/14/15	05:24:45	6.81194		4813.78	-90.74	149.06	
05/14/15	05:40:45	7.07861		4813.80	-90.72	149.62	
05/14/15	05:57:25	7.35639		4813.57	-90.95	150.16	
05/14/15	06:14:50	7.64667		4813.72	-90.80	150.69	
05/14/15	06:32:50	7.94667		4813.71	-90.81	151.21	
05/14/15	06:51:30	8.25778		4813.52	-91.00	151.73	
05/14/15	07:10:50	8.58000		4813.48	-91.04	152.23	
05/14/15	07:31:00	8.91611		4813.52	-91.00	152.74	
05/14/15	07:52:00	9.26611		4813.67	-90.85	153.22	
05/14/15	08:13:50	9.63000		4813.81	-90.71	153.70	
05/14/15	08:36:30	10.00778		4814.07	-90.45	154.18	
05/14/15	09:00:00	10.39944		4814.16	-90.36	154.64	
05/14/15	09:24:30	10.80778		4814.22	-90.30	155.09	
05/14/15	09:49:50	11.23000		4814.51	-90.01	155.54	
05/14/15	10:16:20	11.67167		4814.60	-89.92	155.98	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/14/15	10:43:40	12.12722		4814.77	-89.75	156.43	
05/14/15	11:12:10	12.60222		4815.01	-89.51	156.84	
05/14/15	11:41:50	13.09667		4815.27	-89.25	157.27	
05/14/15	12:12:40	13.61056		4815.40	-89.12	157.67	
05/14/15	12:44:40	14.14389		4815.40	-89.12	158.08	
05/14/15	13:18:00	14.69944		4815.71	-88.81	158.49	
05/14/15	13:52:40	15.27722		4816.10	-88.42	158.88	
05/14/15	14:28:20	15.87167		4816.20	-88.32	159.28	
05/14/15	15:05:40	16.49389		4816.32	-88.20	159.65	
05/14/15	15:44:20	17.13833		4816.64	-87.88	160.03	
05/14/15	16:24:40	17.81056		4816.73	-87.79	160.41	
05/14/15	17:07:00	18.51611		4816.65	-87.87	160.77	
05/14/15	17:50:20	19.23833		4817.03	-87.49	161.13	
05/14/15	18:35:40	19.99389		4817.38	-87.14	161.50	
05/14/15	19:22:20	20.77167		4817.52	-87.00	161.86	
05/14/15	20:11:00	21.58278		4817.36	-87.16	162.22	
05/14/15	21:01:40	22.42722		4817.53	-86.99	162.56	
05/14/15	21:54:20	23.30500		4817.71	-86.81	162.91	
05/14/15	22:50:00	24.23278		4818.00	-86.52	163.26	
05/14/15	23:46:00	25.16611		4818.02	-86.50	163.60	
05/15/15	00:46:00	26.16611		4818.03	-86.49	163.95	
05/15/15	01:47:00	27.18278		4818.36	-86.16	164.27	
05/15/15	02:51:00	28.24944		4818.42	-86.10	164.61	
05/15/15	03:57:00	29.34944		4818.47	-86.05	164.94	
05/15/15	05:06:00	30.49944		4818.56	-85.96	165.27	
05/15/15	06:17:15	31.68694		4818.72	-85.80	165.61	
05/15/15	07:31:40	32.92722		4818.67	-85.85	165.94	
05/15/15	08:28:40	33.87722		4818.17	-86.35	166.16	End falloff test.
05/15/15	08:29:00	33.88278		4818.54	-85.98	166.14	
05/15/15	08:30:00	33.89944		4818.48		166.02	Csg Press = 0 psig.
05/15/15	08:30:30	33.90778	532	4818.35		165.99	POOH making static gradient stops.
05/15/15	08:30:45	33.91194		4803.56		166.36	
05/15/15	08:31:00	33.91611		4785.11		168.13	
05/15/15	08:32:00	33.93278		4702.24		167.72	
05/15/15	08:32:15	33.93694		4682.53		168.82	Arrived at 9000 ft stop.
05/15/15	08:33:05	33.95083		4680.83		168.15	
05/15/15	08:34:05	33.96750		4681.18		167.68	
05/15/15	08:35:05	33.98417		4680.98		167.42	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company: Pinnergy, Ltd.
Well: Highway 67 SWD 1
Field: Newark East (Barnett Shale)
Location: Johnson County, TX
Perfs: 9341 - 11878 ft (MD)
Formation: Barnett Shale

Test Date: 05/12 - 05/15/2015
Gauge Depth: 9300 ft
Gauge Type: Electronic
Gauge SN: SP-79244R
Gauge Range: 15000 psi
Gauge OD: 1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/15/15	08:36:05	34.00083		4681.07		167.26	
05/15/15	08:37:05	34.01750		4680.94		167.17	
05/15/15	08:38:05	34.03417		4680.90		167.10	
05/15/15	08:38:15	34.03694		4680.89		167.09	Left 9000 ft stop.
05/15/15	08:39:05	34.05083		4607.97		162.27	
05/15/15	08:40:05	34.06750		4509.04		156.51	
05/15/15	08:40:40	34.07722		4451.44		153.72	Arrived at 8500 ft stop.
05/15/15	08:41:05	34.08417		4451.23		152.64	
05/15/15	08:42:05	34.10083		4451.06		152.04	
05/15/15	08:43:05	34.11750		4450.96		151.77	
05/15/15	08:44:05	34.13417		4451.20		151.60	
05/15/15	08:45:05	34.15083		4451.34		151.47	
05/15/15	08:46:05	34.16750		4450.95		151.39	
05/15/15	08:46:15	34.17028		4450.94		151.38	Left 8500 ft stop.
05/15/15	08:47:05	34.18417		4372.04		149.84	
05/15/15	08:48:05	34.20083		4265.43		148.46	
05/15/15	08:48:30	34.20778		4222.78		147.86	Arrived at 8000 ft stop.
05/15/15	08:49:05	34.21750		4222.12		146.59	
05/15/15	08:50:05	34.23417		4222.01		146.22	
05/15/15	08:51:05	34.25083		4222.15		146.07	
05/15/15	08:52:05	34.26750		4222.14		145.98	
05/15/15	08:53:05	34.28417		4222.07		145.90	
05/15/15	08:53:55	34.29806		4222.07		145.86	Left 8000 ft stop.
05/15/15	08:54:05	34.30083		4214.38		145.85	
05/15/15	08:55:05	34.31750		4118.92		145.69	
05/15/15	08:56:05	34.33417		4012.51		146.52	
05/15/15	08:57:05	34.35083		3903.39		140.06	
05/15/15	08:58:05	34.36750		3791.98		140.58	
05/15/15	08:59:05	34.38417		3678.92		138.75	
05/15/15	09:00:05	34.40083		3564.38		136.18	
05/15/15	09:01:05	34.41750		3448.75		133.11	
05/15/15	09:02:05	34.43417		3337.76		131.77	
05/15/15	09:02:30	34.44111		3301.03		131.39	Arrived at 6000 ft stop.
05/15/15	09:03:05	34.45083		3301.24		130.97	
05/15/15	09:04:05	34.46750		3301.17		130.84	
05/15/15	09:05:05	34.48417		3301.16		130.77	
05/15/15	09:06:05	34.50083		3301.13		130.72	
05/15/15	09:07:05	34.51750		3301.10		130.69	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/15/15	09:08:05	34.53417		3300.96		130.65	
05/15/15	09:08:20	34.53833		3301.05		130.64	Left 6000 ft stop.
05/15/15	09:09:05	34.55083		3224.85		128.50	
05/15/15	09:10:05	34.56750		3116.42		124.98	
05/15/15	09:11:05	34.58417		3004.23		123.95	
05/15/15	09:12:05	34.60083		2889.51		121.67	
05/15/15	09:13:05	34.61750		2776.45		120.03	
05/15/15	09:14:05	34.63417		2668.94		116.22	
05/15/15	09:15:05	34.65083		2563.17		112.25	
05/15/15	09:16:05	34.66750		2465.04		109.54	
05/15/15	09:17:05	34.68417		2368.05		108.08	
05/15/15	09:18:05	34.70083		2255.60		104.85	
05/15/15	09:19:05	34.71750		2141.66		103.44	
05/15/15	09:20:05	34.73417		2025.36		101.04	
05/15/15	09:21:05	34.75083		1916.69		98.02	Arrived at 3000 ft stop.
05/15/15	09:22:05	34.76750		1916.67		97.15	
05/15/15	09:23:05	34.78417		1916.67		97.04	
05/15/15	09:24:05	34.80083		1916.72		96.96	
05/15/15	09:25:05	34.81750		1916.60		96.88	
05/15/15	09:26:05	34.83417		1916.77		96.83	
05/15/15	09:26:35	34.84250		1916.65		96.81	Left 3000 ft stop.
05/15/15	09:27:05	34.85083		1879.20		96.80	
05/15/15	09:28:05	34.86750		1777.02		95.14	
05/15/15	09:29:05	34.88417		1677.21		94.40	
05/15/15	09:30:05	34.90083		1572.32		91.05	
05/15/15	09:31:05	34.91750		1461.46		89.03	
05/15/15	09:32:05	34.93417		1348.95		86.98	
05/15/15	09:33:05	34.95083		1234.62		84.59	
05/15/15	09:34:05	34.96750		1119.06		82.44	
05/15/15	09:35:05	34.98417		999.71		80.03	
05/15/15	09:36:05	35.00083		879.99		78.43	
05/15/15	09:37:05	35.01750		757.98		76.19	
05/15/15	09:38:05	35.03417		633.47		73.86	
05/15/15	09:39:05	35.05083		541.00		72.22	
05/15/15	09:39:20	35.05500		532.07		71.89	Gauge at surface.
05/15/15	09:40:05	35.06750		530.90		71.04	
05/15/15	09:41:05	35.08417		531.00		70.94	
05/15/15	09:42:05	35.10083		530.96		70.92	

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

RESERVOIR PRESSURE FALLOFF TEST

Company:	Pinnergy, Ltd.	Test Date:	05/12 - 05/15/2015
Well:	Highway 67 SWD 1	Gauge Depth:	9300 ft
Field:	Newark East (Barnett Shale)	Gauge Type:	Electronic
Location:	Johnson County, TX	Gauge SN:	SP-79244R
Perfs:	9341 - 11878 ft (MD)	Gauge Range:	15000 psi
Formation:	Barnett Shale	Gauge OD:	1.2500"

Test Date mm/dd/yy	Real Time hh:mm:ss	Delta Time hours	WHP psia	BHP psia	Delta BHP psi	Temp. °F	Comments
05/15/15	09:43:05	35.11750		531.03		70.93	
05/15/15	09:44:05	35.13417		530.99		70.96	
05/15/15	09:45:05	35.15083		531.02		71.00	
05/15/15	09:46:05	35.16750		530.95		71.03	
05/15/15	09:47:05	35.18417		531.07		71.08	
05/15/15	09:48:05	35.20083		531.07		71.12	
05/15/15	09:49:05	35.21750		530.89		71.16	
05/15/15	09:50:05	35.23417	532	532.09		71.18	Pressured down lubricator.
05/15/15	09:50:20	35.23833		13.58		71.13	Test complete.
05/15/15	09:51:05	35.25083		14.93		71.20	
05/15/15	09:52:05	35.26750		14.79		71.09	
05/15/15	09:53:05	35.28417		14.66		71.07	
05/15/15	09:54:05	35.30083		14.70		71.45	
05/15/15	09:55:05	35.31750		14.67		71.50	
05/15/15	09:56:05	35.33417		14.78		71.53	
05/15/15	09:57:05	35.35083		14.62		71.55	
05/15/15	09:58:05	35.36750		14.77		71.61	
05/15/15	09:59:05	35.38417		14.73		71.63	
05/15/15	10:00:05	35.40083		14.64		71.67	
05/15/15	10:01:05	35.41750		14.57		71.76	
05/15/15	10:02:05	35.43417		15.14		72.33	
05/15/15	10:03:05	35.45083		14.70		73.03	
05/15/15	10:03:30	35.45778		14.82		73.66	Powered down gauge.

Remarks: MIRU slickline. RIH with 1.25" wt bar. Tagged at 11659 ft. POOH. RIH with tandem EMP making static gradient stops to 9300 ft. Suspended EMP on slickline. Conducted 36 hr injection test and 24 hr falloff test. POOH making static gradient stops. RDMO.

Certified: FESCO, Ltd. - Alice, Texas

By: _____

Job No.: J201505130901.001A

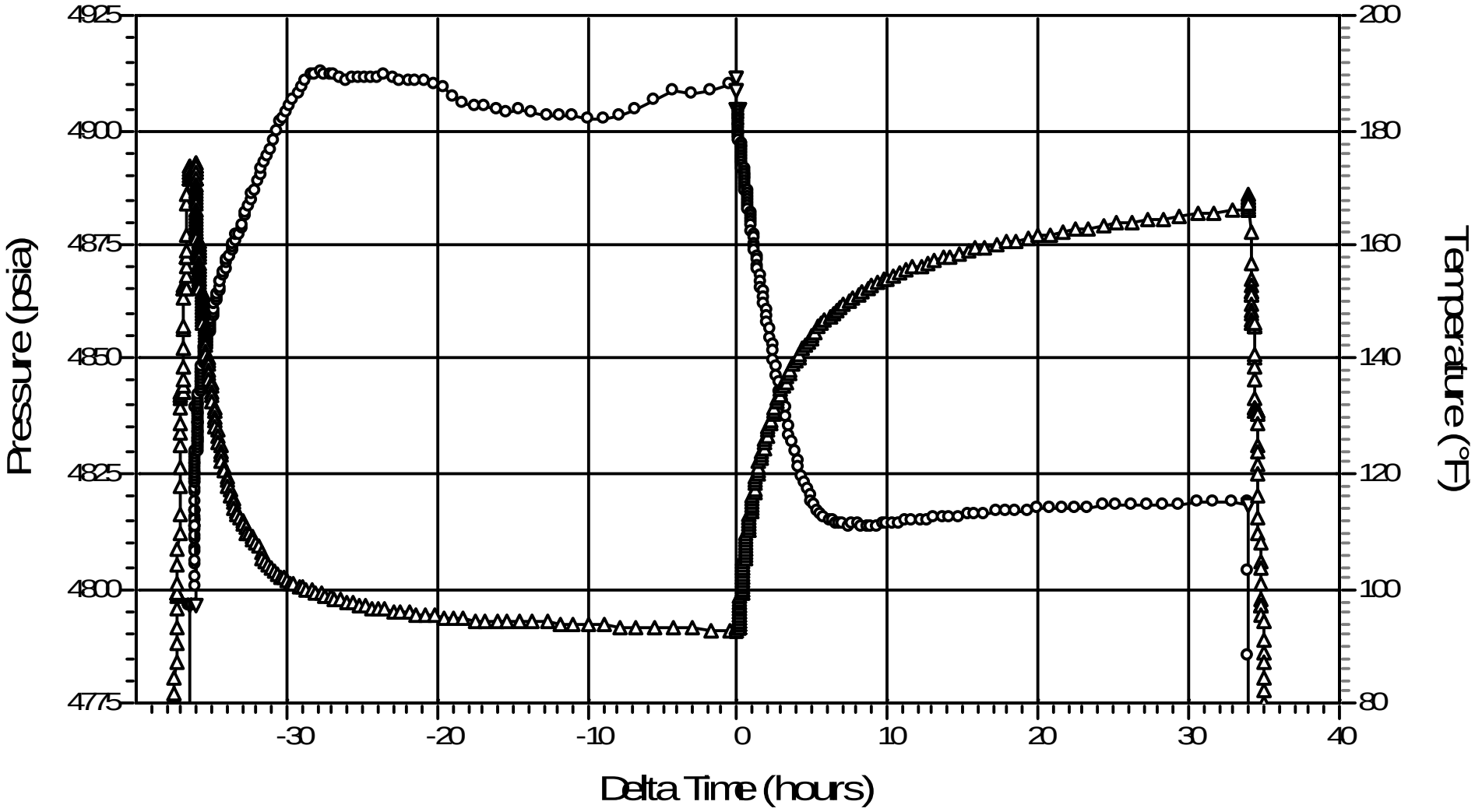
Edwin P. Bickham, P.E.
Vice-President - (361) 661-7000 Ext. 115

Pinnergy, Ltd.

Cartesian Plot

Well: Highway 67 SWD 1
Field: Newark East (Barnett Shale)
Test Date: 05/12 - 05/15/2015

Gauge Type: Electronic
Gauge Range: 15000 psi
Gauge SN: SP-79244R



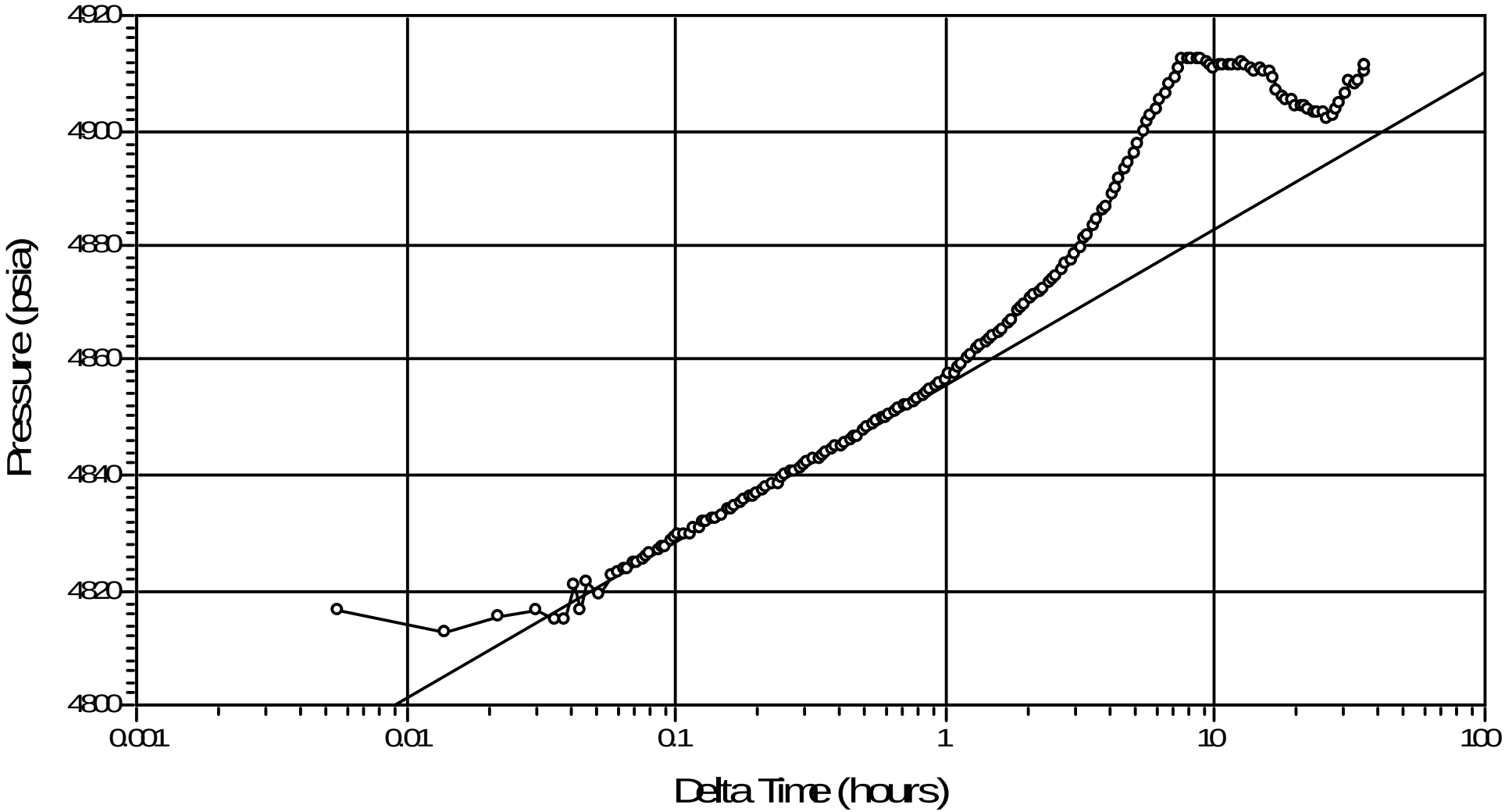
J20150513090 1.001A

Pressure Temperature

Pinnergy, Ltd.

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/12 - 05/13/2015	Gauge SN:	SP-79244R

Semilog Plot (Injection Test)



J20150513090 1.001A

Pinnergy, Ltd.

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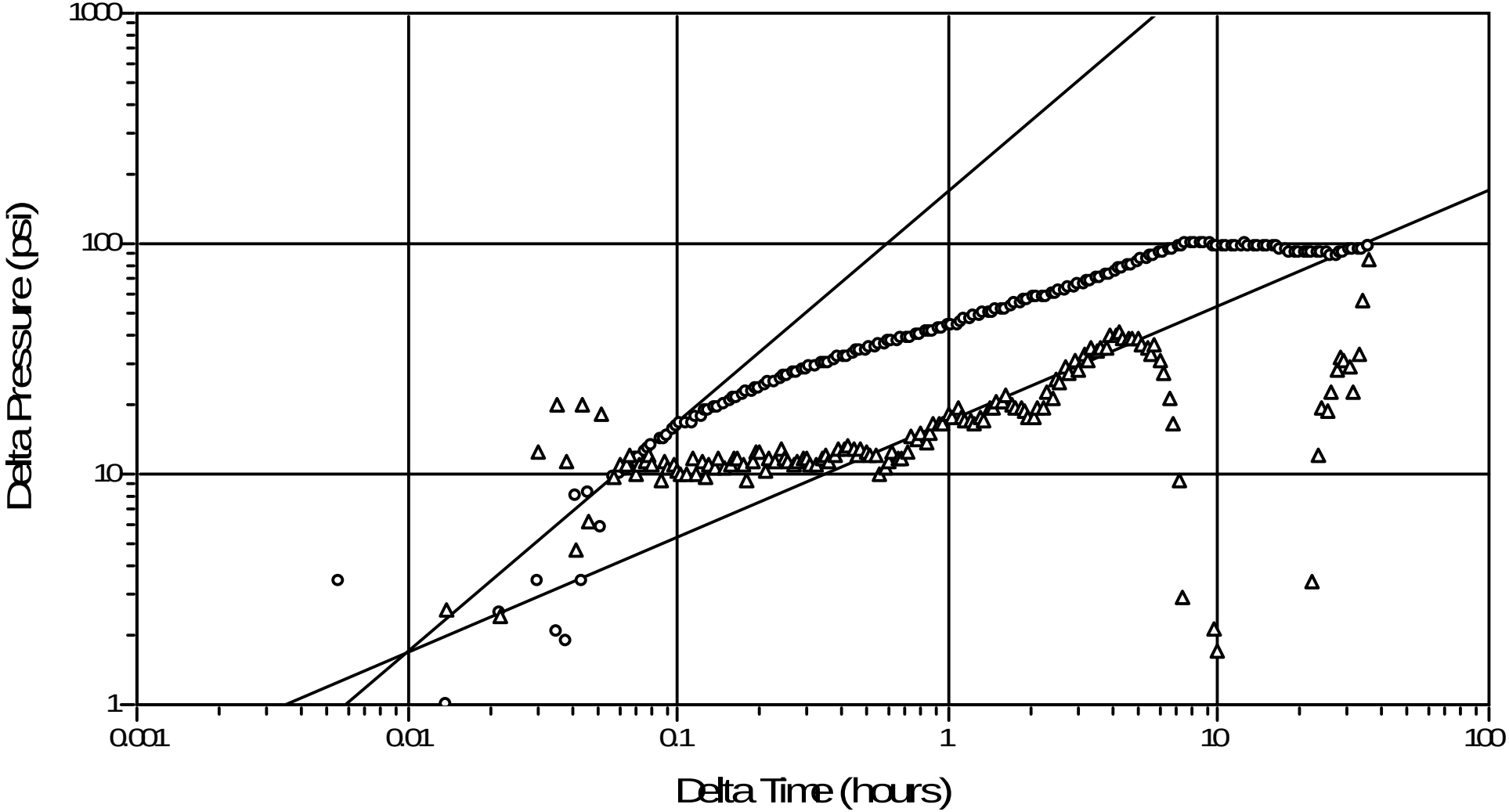
Test Date:	05/12 - 05/13/2015	Gauge SN:	SP-79244R

Log Plot (Injection Test)



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Unit-Slope | Half-Slope | Delta Pressure | Pressure Derivative

Pinnergy, Ltd.

Semilog Plot (Falloff Test)

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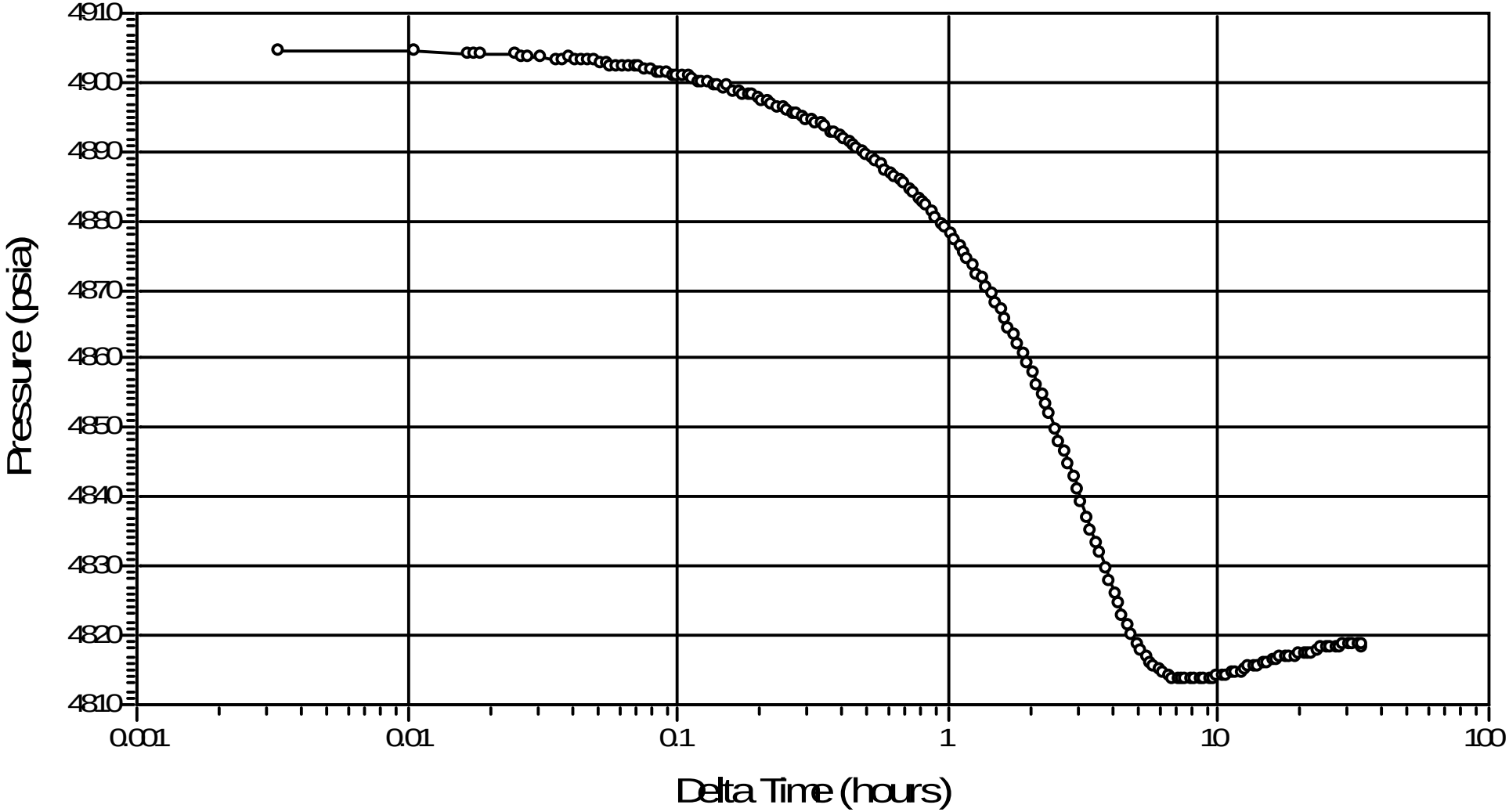
Test Date:	05/12 - 05/15/2015	Gauge SN:	SP-79244R



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Pinnergy, Ltd.

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
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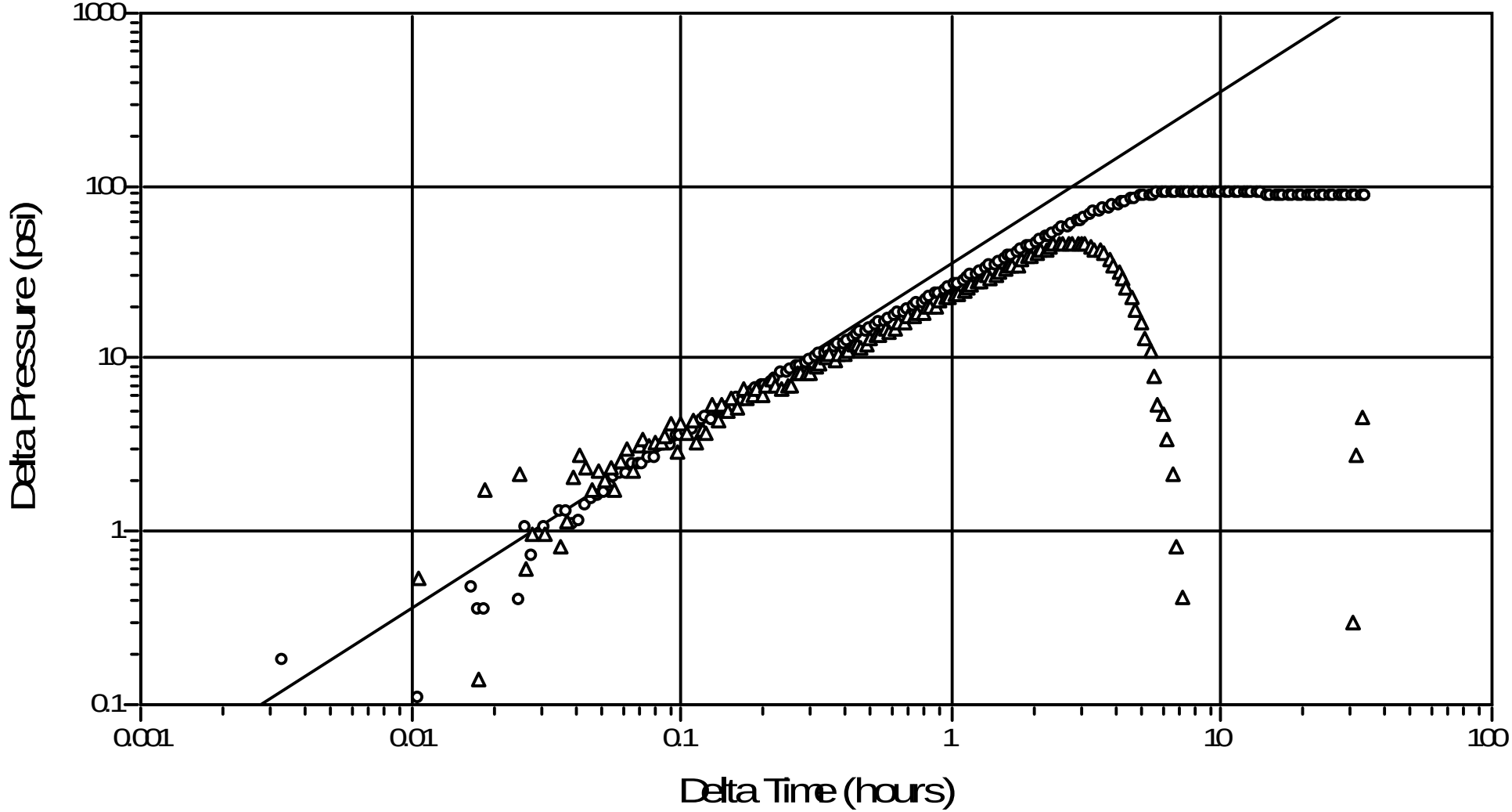
Test Date:	05/12 - 05/15/2015	Gauge SN:	SP-79244R

Log Plot (Falloff Test)



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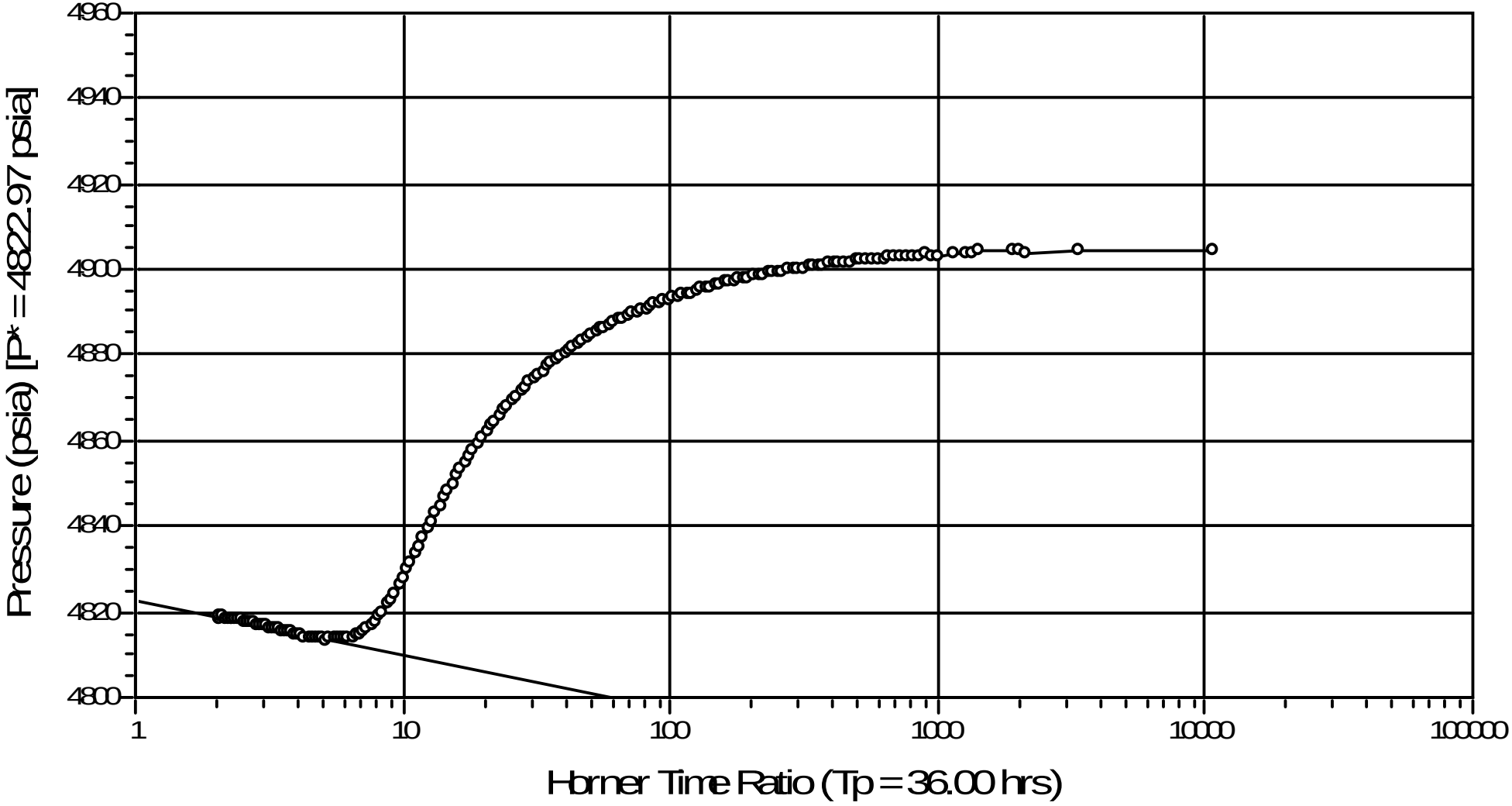
Unit-Slope | Delta Pressure | Pressure Derivative

Pinnergy, Ltd.

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/12 - 05/15/2015	Gauge SN:	SP-79244R

Horner Plot (Falloff Test)



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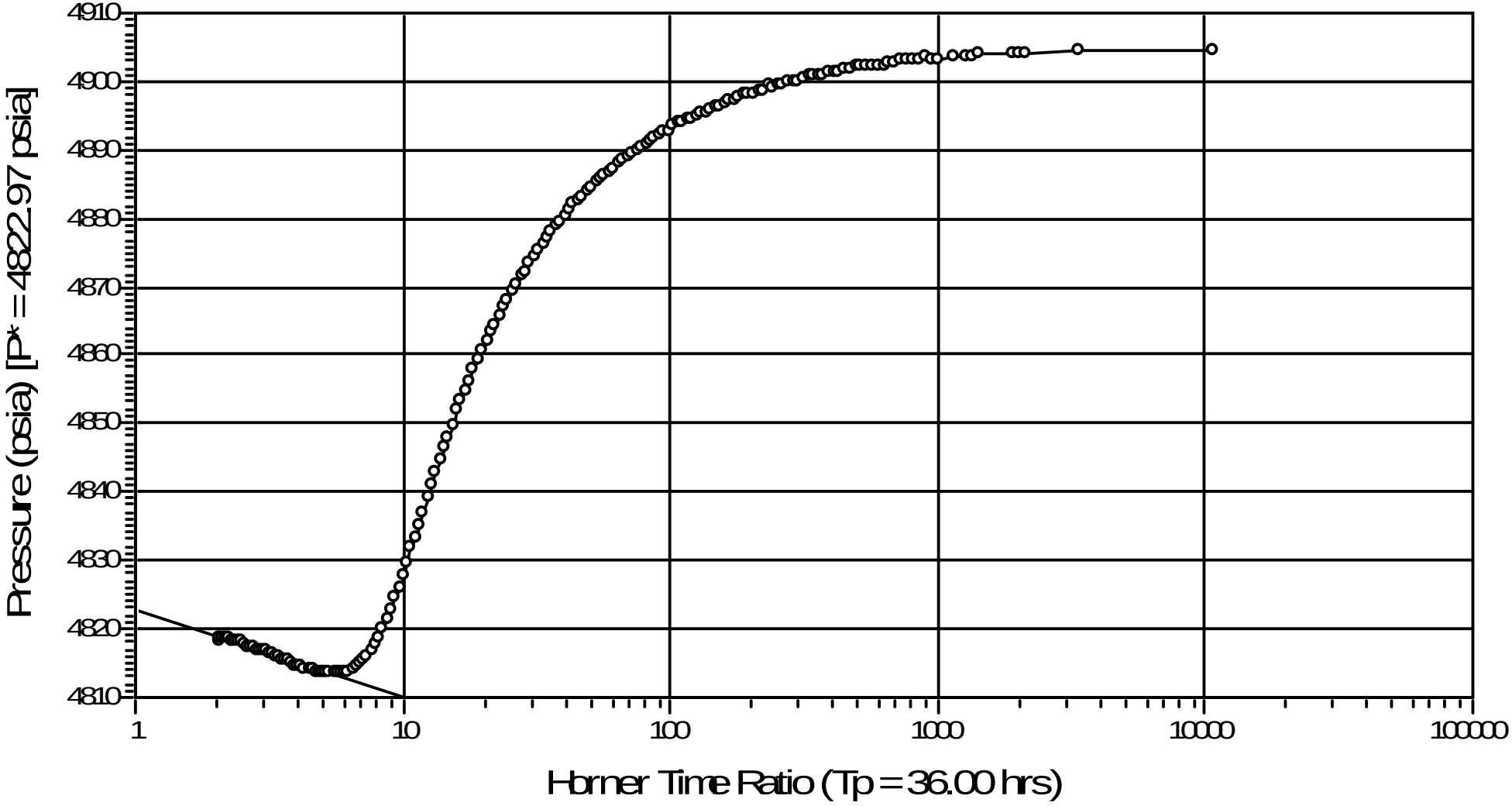
Pinnergy, Ltd.

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/12 - 05/15/2015	Gauge SN:	SP-79244R

Horner Plot (Falloff Test)



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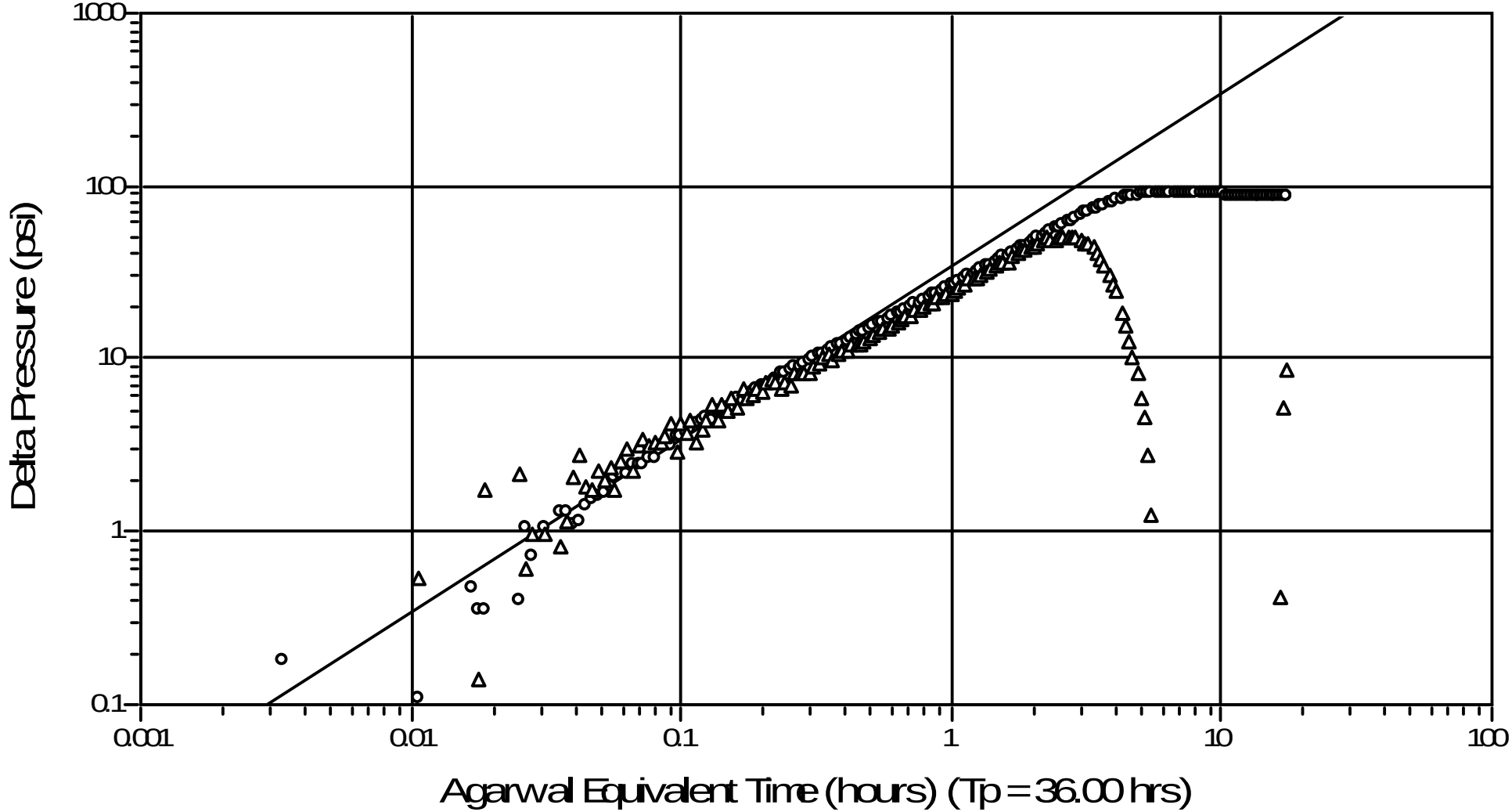
Pinnergy, Ltd.

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/12 - 05/15/2015	Gauge SN:	SP-79244R

Log AET Plot (Falloff Test)



J20150513090 1.001A

Unit-Slope | Delta Pressure | Pressure Derivative

FESCO, Ltd.

1000 Fesco Ave. - Alice, Texas 78332

STATIC GRADIENT SURVEY

Company:	Pinnergy, Ltd.	Test Date:	5/15/2015
Well:	Highway 67 SWD 1	Location:	Johnson County, TX
Field:	Newark East (Barnett Shale)	Status:	Shut in.
Formation:	Barnett Shale		

Well Data:	Wellhead Connection: 3" Regular	Gauge Type:	Electronic
	Elevation: 14 ft above GL	Gauge SN:	SP-79244R
	Tubing: 4" Set at 9283 ft (Packer)	Gauge Range:	15000 psi
	Casing: 7" Set at 9341 ft	Gauge OD:	1.2500"
	Perfs: 9341 - 11878 ft (MD)		
	Datum: 10610 ft (MD)		

Depth			Pressure					
MD ft	TVD ft	Delta Depth ft	WHP psia	BHT °F	Gauge Pressure psia	Delta Pressure psi	Pressure Gradient psi / ft	Comments
0	0	0	532	71.18	532.09	0.00	0.0000	Pressured down lubricator.
3000	3000	3000		96.81	1916.65	1384.56	0.4615	
6000	6000	3000		130.64	3301.05	1384.40	0.4615	
8000	8000	2000		145.86	4222.07	921.02	0.4605	
8500	8500	500		151.38	4450.94	228.87	0.4577	
9000	9000	500		167.09	4680.89	229.95	0.4599	
9300	9300	300	532	165.99	4818.35	137.46	0.4582	POOH making static gradient stops.

BHT at Test Depth:	166.0 °F	Oil Level:	None	Previous BHP:	U/A
Extrapolated BHP at Datum:	5418.59 psia	Water Level:	Surface	BHP Change:	U/A
BHP Gradient at Datum :	0.4582 psi/ft	Csg Press:	N/A		

Remarks: MIRU slickline. RIH with 1.25" wt bar. Tagged at 11659 ft. POOH. RIH with tandem EMP making static gradient stops to 9300 ft. Suspended EMP on slickline. Conducted 36 hr injection test and 24 hr falloff test. POOH making static gradient stops. RDMO.

Certified: FESCO, Ltd. - Alice, Texas

Job No.: J201505130901.002A

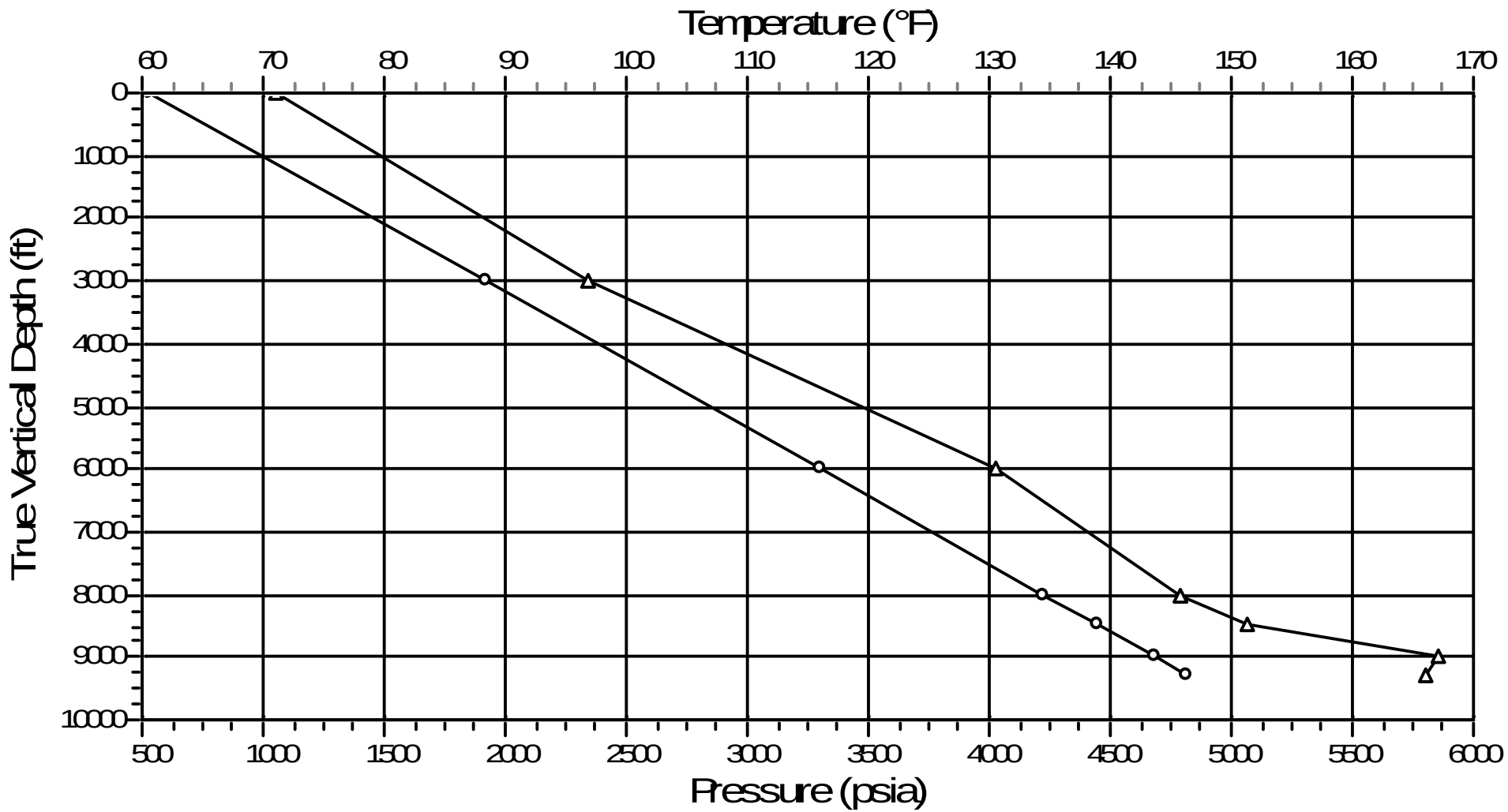
By: _____

Edwin P. Bickham, P.E.
Vice-President - (361) 661-7000 Ext. 115

Pinnergy, Ltd.

Static Gradient Plot

Well:	Highway 67 SWD 1	Gauge Type:	Electronic
Field:	Newark East (Barnett Shale)	Gauge Range:	15000 psi
Test Date:	05/15/2015	Gauge SN:	SP-79244R



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APPENDIX

VII-6 Eaton Injection Gradient Method

APPENDIX VII-6 Eaton Injection Gradient Model

Fracture Gradient Prediction and Its Application in Oilfield Operations

Ben A. Eaton, SPE-AIME, Continental Oil Co.

Introduction

The subject of many discussions and technical papers in the last 20 years has been the prediction of the wellbore pressure gradients that are required to induce or extend fractures in subsurface formations. The subject merits this attention because of the frequently recurring problems that arise from an inability to predict fracture pressure gradients.

Encountered in several common types of operations in the oil industry are problems associated with the prediction of formation fracture pressure gradients. When wells are being drilled in both new and old fields, lost circulation is often a very troublesome and expensive problem. Complete loss of circulation has been disastrous in some cases. Many times, such disasters could have been avoided if techniques for calculating fracture pressure gradient had been employed in the well plans, and if casing strings had been set, and mud weight plans had been followed accordingly. In areas of abnormally pressured formations, the prediction of fracture gradients during the well-planning stage is extremely important. In fact, it is as important as the prediction of formation pressure gradients, which has received a great deal of attention in recent years.

There are several published methods used to determine fracture pressure gradients. However, none of these methods appears to be general enough to be used with much reliability in all areas. In 1957, Hubbert and Willis published a classical paper that included the development of an equation used to predict the fracture extension pressure gradient in areas of incipient normal faulting.[1] Overburden stress gradient, formation pore pressure gradient and Poisson's ratio of rocks were the independent variables that were shown to control fracture pressure gradient, the dependent variable.

In 1967, Matthews and Kelly published another fracture pressure gradient equation that is different from that of Hubbert and Willis in that a variable "matrix stress coefficient" concept was utilized.[3] Later the same year, Costley wrote about a similar idea.[5]

Goldsmith and Wilson used a least-squares curve-fitting technique and field data from the Gulf Coast area to correlate fracture pressure gradient with formation pore pressure gradient and formation depth.[4] They noted that the fracture pressure gradient increased with increasing depth while the pore pressure gradient remained constant.

In each of these cases, the problem for which a solution was sought was to determine the bottom-hole pressure gradient required to initiate or extend a fracture. Results of the previous work show that fracture pressure gradient is a function primarily of overburden stress gradient, pore pressure gradient, and the ratio of horizontal to vertical stress. There is argument for a fourth variable in that in many cases breakdown fracture pressure gradient is greater than the fracture extension pressure gradient. However, if the fracturing fluid is able to penetrate the formation through the pores or existing cracks, there is very little

In arriving at a new method of predicting formation fracture gradients, it was found that overburden load, Poisson's ratio for rocks, and pressure gradients vary with depth. Although the method was developed specifically for the Gulf Coast, it should be highly reliable for all areas, provided that the variables reflect the conditions in the specific area being considered.

This page of *Petroleum Transactions, AIME* follows page 1216. The intervening non-Transactions pages appeared in *Journal of Petroleum Technology*.

difference in the two fracturing pressure gradients. Therefore, since field data are used here and since it is not possible to know for certain whether or not a wellbore contains natural fractures or faults, this difference will not be discussed further.

One independent variable that partially controls the fracture pressure gradient is the formation pore pressure gradient. Formation pressure gradients may be calculated from logs or determined by bottom-hole pressure bombs. Since formation pore pressure is not the subject of this paper, it is assumed that accurate formation pressure data are available to use in the fracture pressure gradient calculations.

Another important variable is the overburden stress gradient. Overburden stress gradient is normally assumed to be 1.0 psi/ft. But this is a high average value for a nonconstant variable, and one should realize that it may be seriously in error in some areas, such as on the Gulf Coast at shallow depths.

The amount of horizontal stress caused by the vertical stress (net overburden) is a function of Poisson's ratio of the rocks in question and is another important variable. The horizontal-to-vertical stress ratio has been considered to be constant with depth in many cases, and equal to one-third. This corresponds to a Poisson's ratio equal to 0.25. However, this frequently used average value for Poisson's ratio for rocks may well be in error. Values from laboratory experiments vary from well under to well over 0.25, but are never greater than 0.50.[7]

Several authors have questioned the foregoing assumptions. Hence, it seems worthwhile to review and compare the various techniques used to calculate fracture pressure gradients. To do so, the data of Figs. 1A and 1B were used to calculate the fracture pressure gradient by several methods.

Previous Methods of Predicting Fracture Pressure Gradient

Hubbert and Willis showed the fracture pressure gradient to be a function of overburden stress gradient, formation pressure, and stress ratio.[1] This leads to Eq. 1:

$$\frac{p_w}{D} = \left(\frac{S}{D} - \frac{p}{D}\right)\left(\frac{\nu}{1-\nu}\right) + \frac{p}{D}. \quad . \quad . \quad (1)$$

When the assumptions are made that $S/D = 1.0$ and $\nu = 0.25$, Eq. 1 reduces to

$$\frac{p_w}{D} = \left(1.0 + \frac{2p}{D}\right) \cdot \frac{1}{3} \quad , \quad . \quad . \quad . \quad . \quad (2)$$

which is known as the Hubbert and Willis equation. Under these conditions, the fracture gradient is calculated to be a constant with increasing depth for all normally pressured formations. This is known to be untrue for many cases in the Gulf Coast. Actually, Eq. 2 predicts values that are usually too low compared with values from field data. However, this does not mean that Eq. 1 is invalid. It is more probable that the assumptions used to obtain Eq. 2 are in error. Eq. 2 was used for comparative purposes to calculate Curve 2 of Fig. 2, using the pressure gradient curve data (Curve 1 of Fig. 2) as determined from the log data of Figs. 1A and 1B. Note that p_w/D increases only when p/D increases. Similarly, the log data for Well B were used with Fig. 1B to determine the pressure gradient of Well B. The results make up Curve 1 of Fig. 5. Curve 2 of Fig. 5 shows the fracture gradient computed by the Hubbert and Willis equation. The same behavior is to be observed as in the first example. However, experience has shown that p_w/D increases with depth, regardless of the pressure be-

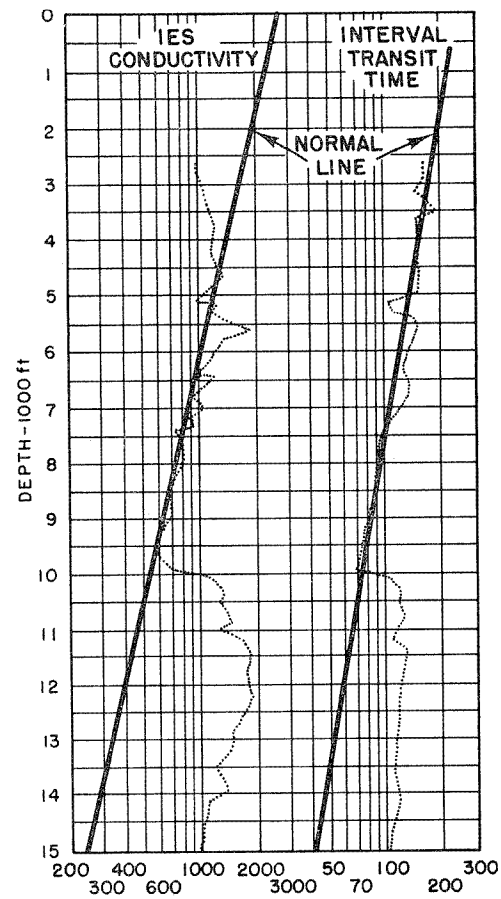

Fig. 1A—Log data from Frio formation, Nueces County, Tex.[3]

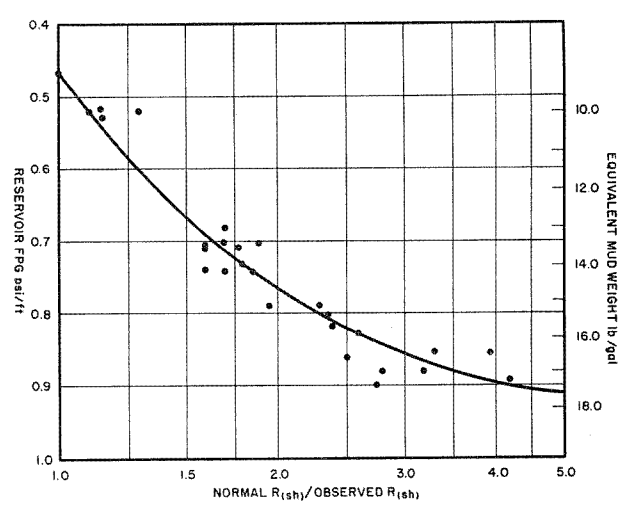

Fig. 1B—Relationship between shale resistivity parameter $R_{n(sh)}/R_{ob(sh)}$ and reservoir fluid pressure gradient.[8]

havior, until the abnormal pressure section is traversed. Then p_w/D may decrease as shown by the other curves in Figs. 2 and 5.

Matthews and Kelly[3] presented a fracture gradient equation similar to Eq. 1. However, they introduced the concept of a variable horizontal-to-vertical stress ratio. Fig. 3 is a reproduction of their curves showing the variable stress ratio as a function of depth for two areas. Again one must assume that the overburden load is 1.0 psi/ft. To calculate a fracture gradient by this method one must use the following procedure.

1. Obtain the formation pore pressure.
2. Determine the effective stress, $\sigma = 1.0\,D - p$.
3. Determine the depth D_i for which the matrix stress σ would be the normal value:

$$D_i = \frac{\sigma}{0.535}.$$

4. Use the value of D_i from the preceding step with Fig. 3 to determine K_i.
5. With the resulting data, calculate the fracture gradient using the Matthews and Kelly fracture gradient equation, which follows:

$$\frac{p_w}{D} = K_i\left(\frac{\sigma}{D}\right) + \frac{p}{D} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

(Note: Matthews and Kelly call this the *breakdown* gradient and say that it is higher than the fracture *extension* gradient.)

6. Plot the fracture gradient as a function of depth.

In this manner, Curve 4 of Fig. 2 and Curve 3 of Fig. 5 were generated. The effect of depth and formation pressure is readily evident. However, there appear to be two weaknesses in the approach, one of which is the assumption that the overburden stress is equal to 1.0 psi/ft of depth. The other weakness is that the stress ratio used in calculating the fracture gradient in abnormally pressured formations is that of the deepest normally pressured formation. The Matthews and Kelly approach represents a significant advancement in fracture gradient technology, and the variable stress ratio concept is quite valid when compared with field data analysis.

Recently, Goldsmith and Wilson[4] found that the presently existing techniques for calculating fracture gradients were inadequate. Using a great deal of data on lost circulation and squeeze pressure, they developed empirical equations, using least-squares curve-fitting, that appear to predict very well the fracture gradients for a localized area. The equations are long and somewhat difficult to use, but this technique was employed in calculating Curve 5 of Fig. 2. The vast disagreement of these techniques is well illustrated.

Costley[5] recently published yet another technique that is similar to the Matthews and Kelly method. The same basic assumptions are involved; therefore, the method will not be discussed further. Nevertheless, the data published by Costley were used with other data to develop the method that follows.

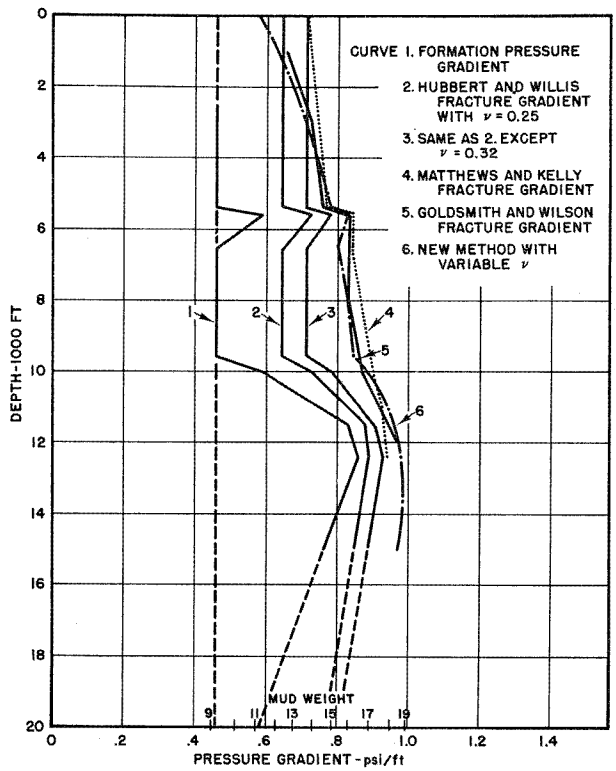

Fig. 2—Formation and fracture pressure gradients.

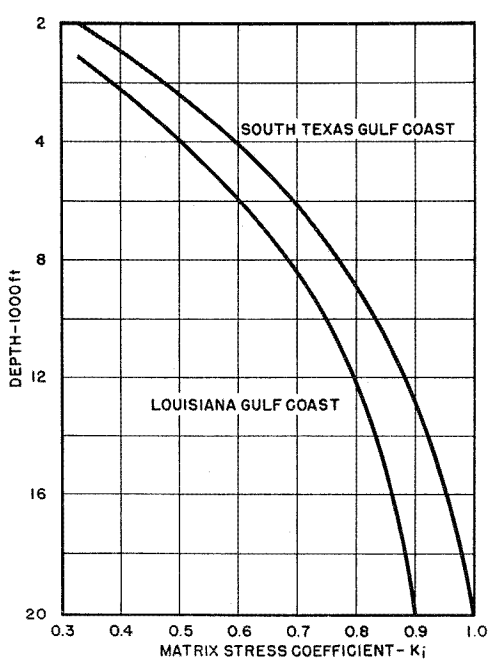

Fig. 3—Matrix stress coefficient.[3]

A Revised Approach

Throughout the remainder of this work, it is postulated that the assumptions leading to Eq. 1 are valid and that all of the independent variables are functions of depth. The problem is to determine the relationship of overburden stress, pore pressure, and Poisson's ratio with depth. Since it is accepted here that abnormal formation pressure gradients may be determined from logs, that aspect of the problem is solved. The next steps are to assume that the overburden stress gradient is 1.0 psi/ft, then to solve Eq. 1 for the stress ratio group

$$\frac{\nu}{1-\nu}=\frac{\frac{p_w}{D}-\frac{p}{D}}{\frac{S-p}{D}}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and to evaluate Eq. 4 with field data.

A great deal of data from the analysis of hydraulic fracturing treatments in West Texas was published by Crittendon.[6] These data were used to develop the left curve of Fig. 4. It can be seen that for the producing formations of the West Texas area, the assumptions $S/D = 1.0$ and $\nu = 0.25$ are valid.

Data given by Costley were used to back-calculate the middle Poisson ratio curve of Fig. 4. Note the curvature of the trend of Poisson ratio vs depth for the Gulf Coast area. This is caused by the sediments' being younger and more compressible near the surface, but less compressible and more plastic with depth. For this reason the curve approaches 0.5 as an upper limit. This limit is the Poisson ratio of an incompressible material in the plastic failure environment.

Example results of fracture pressure gradient calculations using the middle Poisson ratio curve of Fig. 4 and Eq. 1 are included for comparative purposes. These are shown by Curve 6 of Fig. 2 and Curve 4 of Fig. 5.

From the preceding calculations it becomes evident that the variation of overburden stress with well depth must be determined where formations are compressible, such as in the Gulf Coast area. A composite group of density logs from many Gulf Coast wells was available. These logs were used to plot bulk density vs depth, which is shown in Fig. 6. The values for bulk density were read at the mid-point of each 1,000-ft interval and averaged step by step downward to 20,000 ft of depth. In this manner, the overburden stress curve of Fig. 7 was produced. The value of overburden stress read from the curve at any depth represents the real average overburden gradient at that specific depth. Further averaging need not be done.

The same procedure was used for similar data from wells in the Santa Barbara Channel. Bulk densities from logs and the resulting overburden stress gradient curve are shown in Figs. 10 and 11, respectively, with the results being similar to those given in Figs. 6 and 7. It was concluded that variable overburden stress gradient curves, as determined from density logs of good quality, are far superior to any assumed constant number.

Based on Eq. 4, the same field data, and Fig. 7, the Poisson ratio trend for the Gulf Coast area was back-calculated and plotted on the right side of Fig. 4. Note that this curve approaches the middle curve at greater depths where the overburden stress gradient does approach 1.0 psi/ft. It was concluded that Figs. 4 and 7 could be used with formation pressure data and Eq. 1 to predict accurately the fracture gradients in the Gulf Coast. The same method will apply in other areas, provided that the overburden stress gradient and Poisson ratio curves are determined from good data.

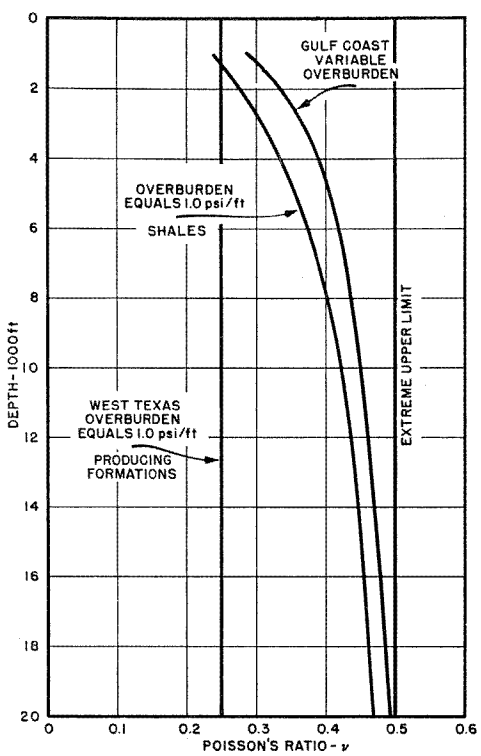

Fig. 4—Variation of Poisson's ratio with depth.

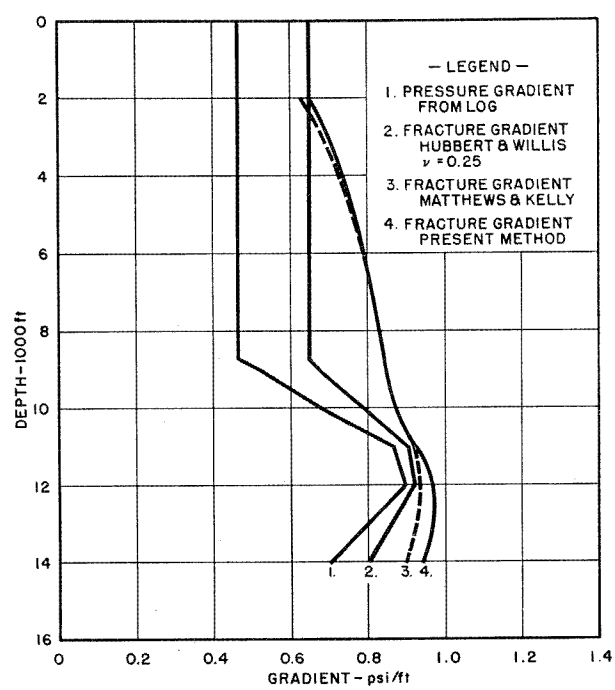

Fig. 5—Well B, East Cameron.
Fracture pressure gradient comparison.

The preceding discussion illustrates a method whereby all three variables that control the fracture pressure gradient are determined from well data. A nomograph for solving Eq. 1 to predict fracture pressure gradients is shown, with an example calculation, in Fig. 12.

How to Apply the New Technique

To demonstrate better how to apply this method of predicting fracture gradients, an example follows, showing how the technique should be employed in drilling well plans.

1. Fig. 8 shows a plot of resistivities for a well in the East Cameron area. Data from Fig. 8 are used with Fig. 1B to produce the formation pressure curve of Fig. 9. Mud weights for this area should be determined in this manner during the well planning stage. The mud weight scale at the bottom of Fig. 9 and the formation pressure gradient curve dictate the minimum mud weight program.

2. The next step is to determine and plot fracture gradient vs depth. (This is illustrated in Fig. 9, which shows five fracture gradient curves.) It is assumed that the overburden gradient averages 0.8 psi/ft all the way down. The graphic solution of Eq. 1 shown by Fig. 12 is used with the variable Poisson's ratio curve (right-hand curve of Fig. 4) to find the fracture gradient vs depth. The process is repeated for assumed overburden stress gradients of 0.9, 1.0, and 1.1 psi/ft. These four fracture gradient curves are *not* correct, because the overburden gradient varies with depth according to the curve of Fig. 7. However, all that must be done to arrive at the correct fracture gradient curve is to use Fig. 7 and interpolate between the various gradients of Fig. 9. The interpolation is shown as the correct fracture gradient curve on Fig. 9. Note that near the surface, the curve is between the 0.8 and 0.9 curves, and at the 4,000 ft mark it crosses the 0.9 curve and approaches the 1.0 curve with depth. This illustrates somewhat elaborately the effect of overburden stress gradient on fracture pressure gradient. However, in actual practice only the true fracture gradient should be used.

3. The casing points can be selected by making use of the formation pressure gradient curve (minimum mud weight curve) and the true fracture gradient curve. In the example of Fig. 9, surface pipe was set at 3,100 ft. If we assume that minimum mud weights were used during drilling, a protective string of pipe must be set at no deeper than 10,400 ft. A vertical line from the pressure gradient curve at 10,400 ft extends upward to a point slightly above that representing the surface pipe shoe. In this case, breakdown and lost circulation would not occur. However, if drilling were to continue to 11,000 ft before a protective string is set, breakdown would occur. A vertical line from the pressure gradient curve at the 11,000 ft mark extends up and intersects the fracture gradient curve at the 5,000 ft mark. Breakdown would occur anywhere between 5,000 and 3,100 ft of depth. This is simply to say that casing points should be selected by using both the formation pressure and the fracture

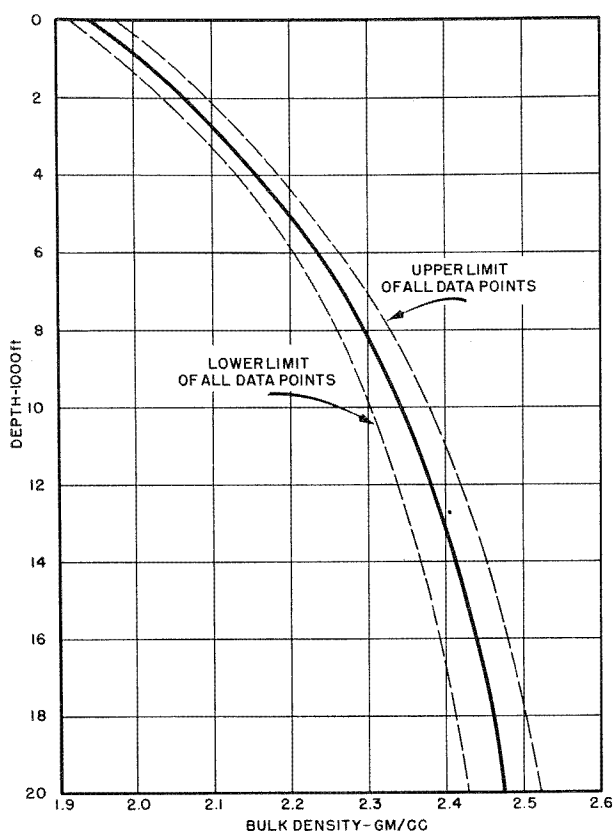

Fig. 6—Composite bulk density curve from density log data for the Gulf Coast.

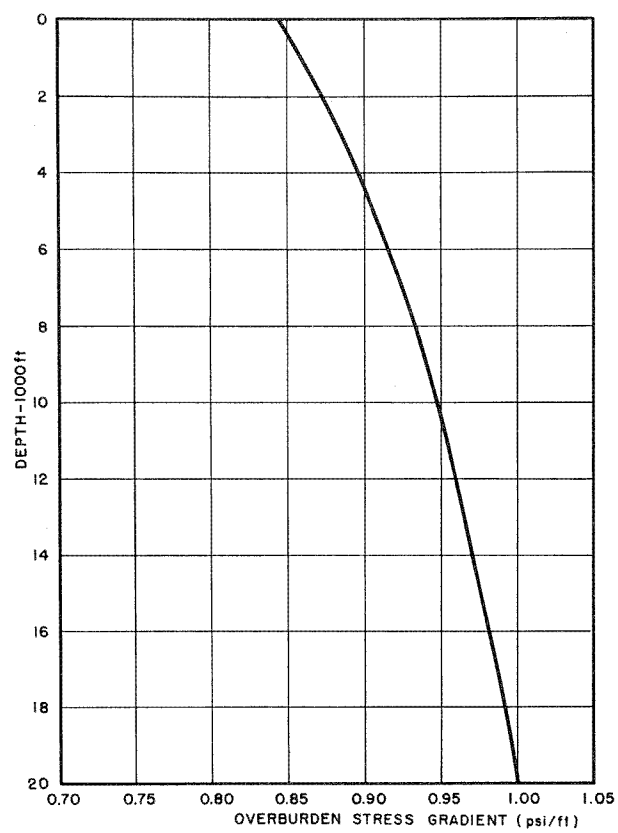

Fig. 7—Composite overburden stress gradient for all normally compacted Gulf Coast formations.

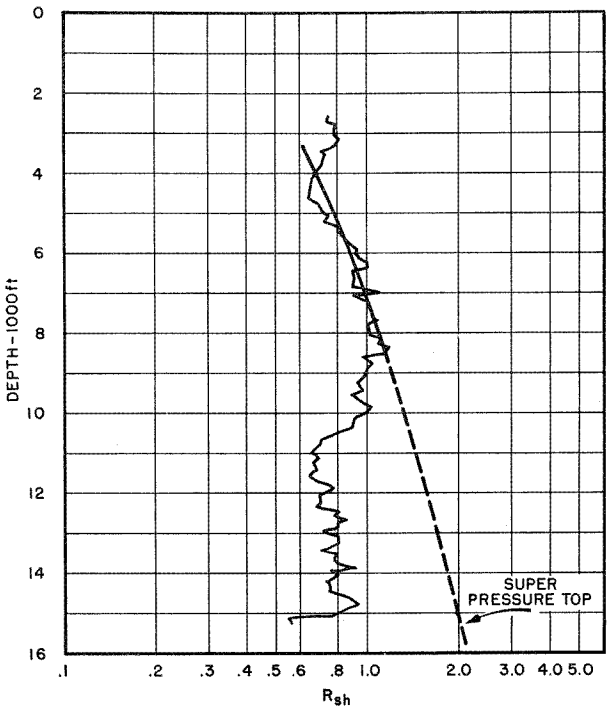

Fig. 8—Log data, Well C, East Cameron.

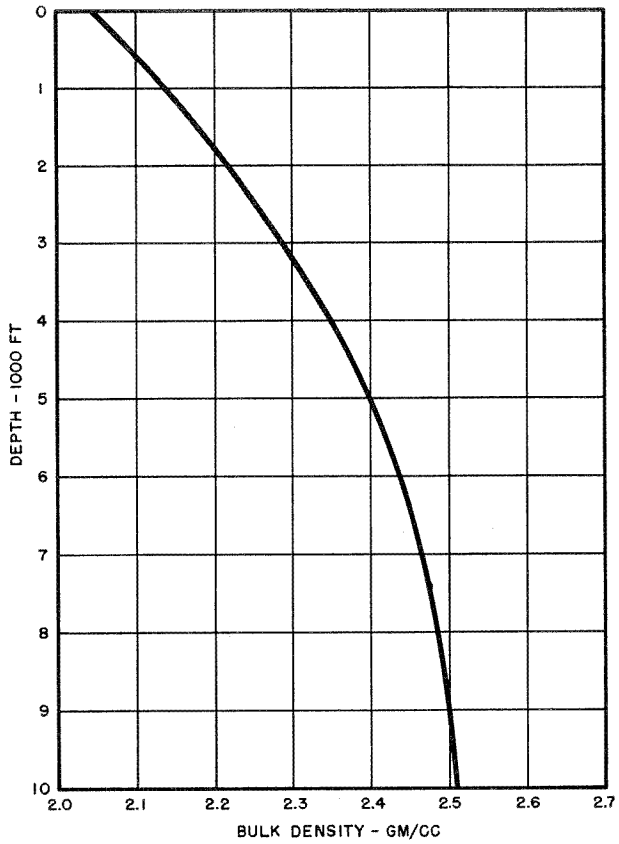

Fig. 10—Bulk density curve from density logs, Santa Barbara Channel.

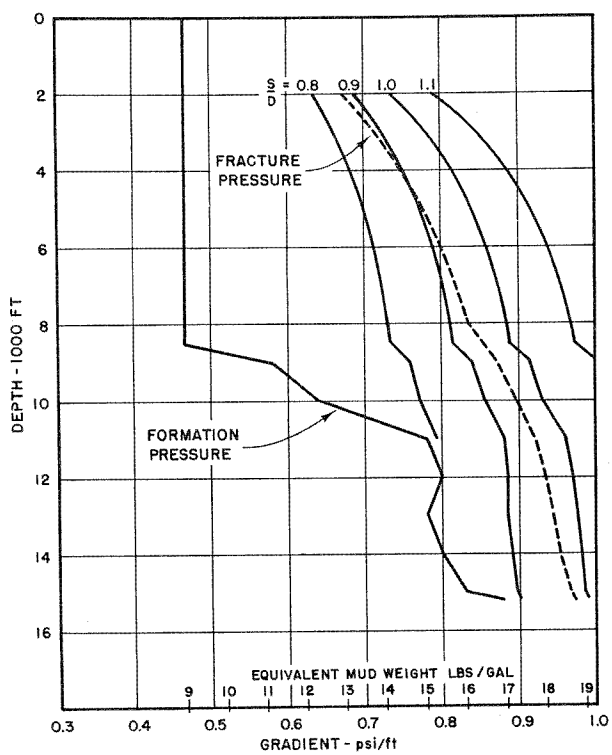

Fig. 9—Fracture gradient with variable overburden and Poisson's ratio included, Well C, East Cameron.

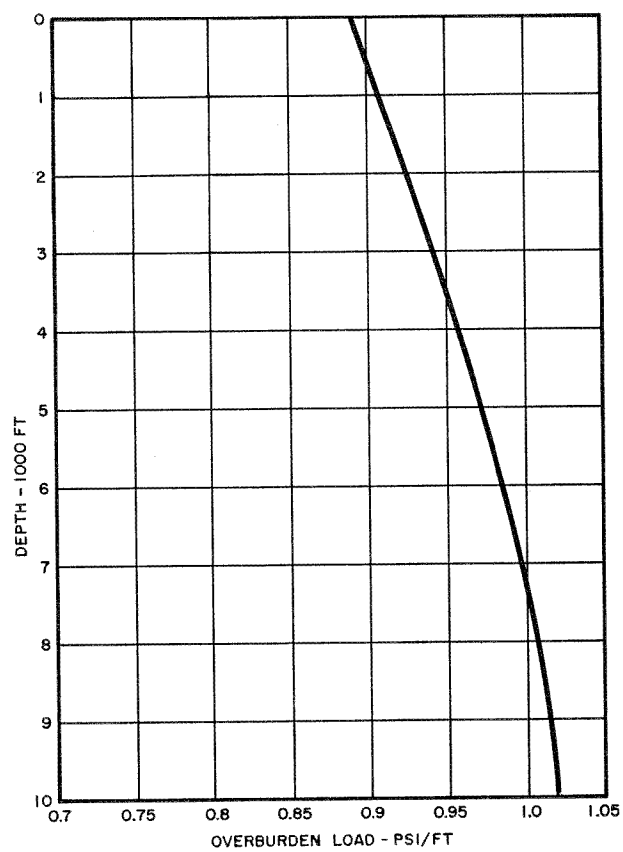

Fig. 11—Overburden stress gradient, Santa Barbara Channel.

gradient plots. All of the foregoing serves to illustrate the application of fracture gradient prediction techniques in drilling well plans.

Other Applications

A knowledge of fracture gradient prediction methods is extremely useful in such everyday operations as cementing, sand consolidating, matrix and fracture acidizing, and hydraulic fracturing.

Another important application is in secondary recovery. In most injection operations, it is desirable to stay below the fracturing pressures to prevent channeling from injector to producer. Of course, in the event that such vertical fractures all line up parallel with lines of injectors, good linear sweep patterns result. In such cases, the general direction of the fractures should be determined and injection and producing wells should be lined up to take advantage of induced fractures.

In many cases, injection is started in old wells that have been producers for years. Here the formation pressures are usually very low in the surrounding formation. Low formation pressures cause low fracture pressure, much the same as high formation pressures cause high fracture pressures. Eq. 1 predicts this behavior. However, more vivid proof is given in Fig. 13, in which the results of a pressure-rate test are shown.

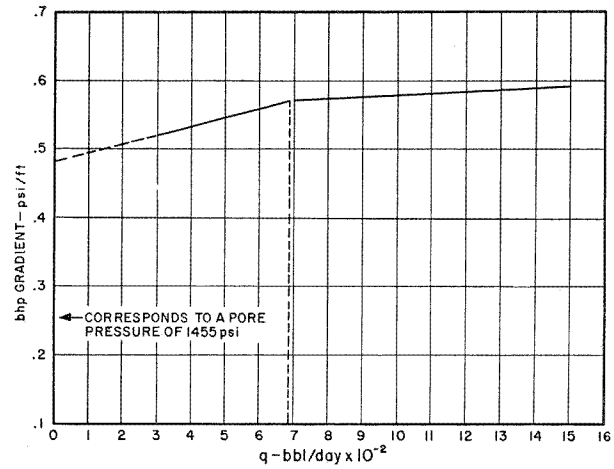

Fig. 13—Fracture gradient of a West Texas water injection well.

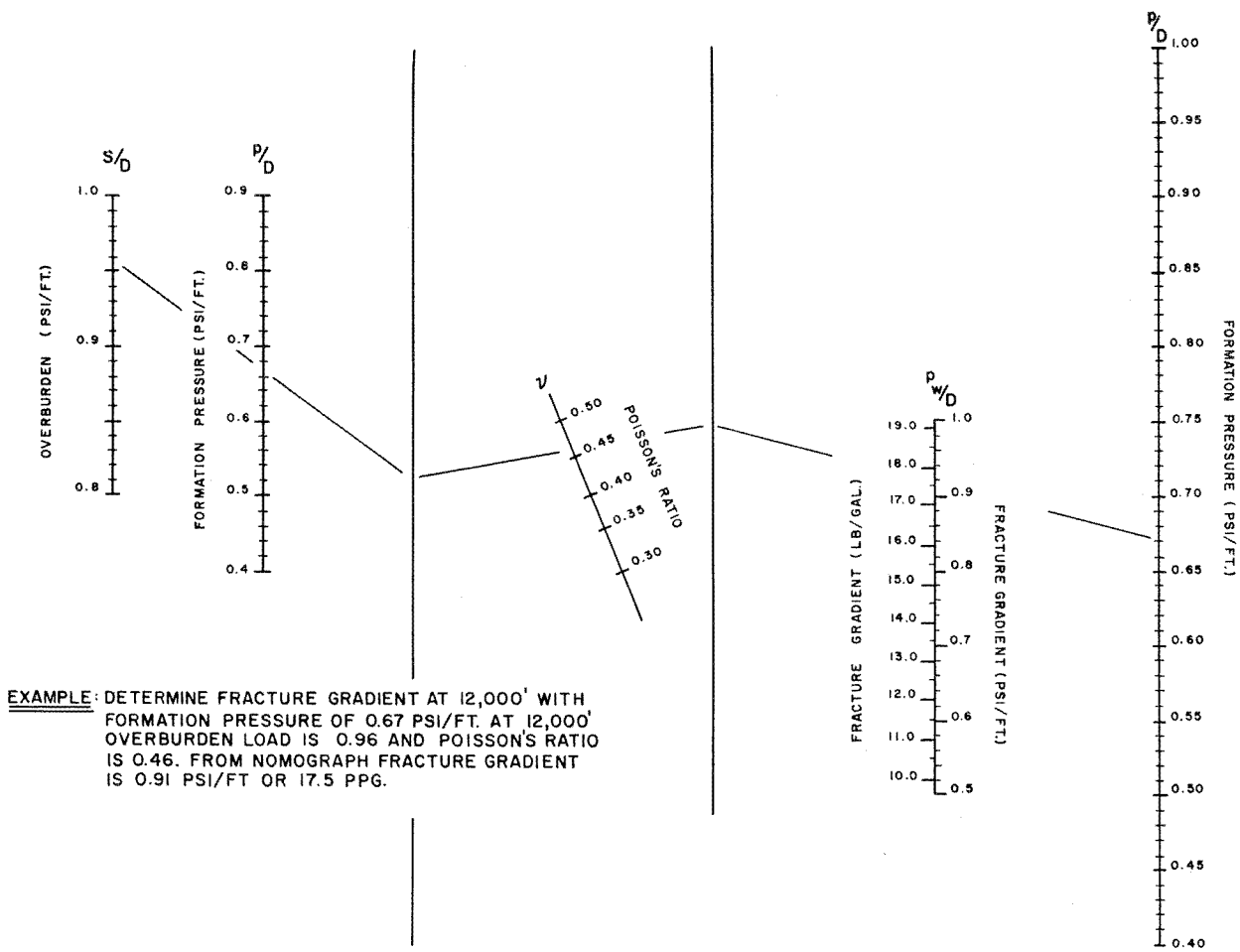

Fig. 12—Fracture gradient nomograph.

Fracturing occurred when a gradient of 0.57 psi/ft was reached, as shown by the sudden change in slope at about 700 B/D injection. New in-fill wells in the same area are hydraulically fractured with gradients of 0.68 to 0.70 psi/ft. The relatively low fracture gradients of old producers are due to low formation pressures. Many old producing wells are fractured unintentionally when converted to injection wells. The pressure in the producing formation is so low that it cannot withstand even the gradient of fresh water.

One more example of the effect of formation pressure on fracture gradient is that three pressure-rate tests were run on a California injector on Dec. 13, 1961; June 11, 1962; and Dec. 3, 1962. Fracture pressure gradients were determined at sudden changes in slope of pressure-rate plots. These gradients were 0.748, 0.864, and 0.993 psi/ft on their respective dates. These data illustrate how the fracture pressure gradient is affected by changes in formation pressure around a wellbore.

How to Develop the Technique for Other Areas

The data necessary to develop this method for other tectonically relaxed areas of the earth are as follows:

1. Overburden stress gradient vs depth. Such data can be derived from bulk densities taken from logs, seismic data or shale density measurements. A plot of bulk density vs depth can then be converted to a plot of average overburden stress gradient vs depth.
2. Actual fracture pressure gradients for several depths. These can be lost-circulation or squeeze data or actual fracturing data.
3. Formation pressures that apply to the data in Item 2. (In Items 2 and 3, the depths must correspond.)

With these data and Eq. 4, the Poisson's ratio curve for the area can be back-calculated and plotted vs depth. The result will be a curve similar to those of Fig. 4 and a curve similar to that of Fig. 7. With these curves and Fig. 12, fracture gradients can be predicted quite easily and quickly. These values can be plotted as a function of depth and the resulting curves can be used in all the operations previously described.

Conclusions

In summary, several conclusions have been drawn.

1. In drilling well plans, well stimulation plans, and secondary recovery plans, fracture pressure gradient should be considered.
2. Poisson's ratio for rocks increases with depth in the Gulf Coast area.
3. The Poisson's ratio trend, which can be back-calculated using field data, will not be exactly the same for data from different areas.
4. In the Gulf Coast area, the average overburden stress gradient does not equal 1.0 psi/ft, but instead is about 0.85 psi/ft near the surface and increases smoothly to 1.0 psi/ft at about 20,000 ft of depth. A similar trend has been established for the Santa Barbara Channel area.
5. The present method is a modification of the Hubbert and Willis approach, using a variable Poisson ratio and a variable overburden stress gradient with depth. The method will predict the fracture gradient for the Gulf Coast area with as much accuracy as the log-derived pressure gradient.
6. Using this approach and field data, the same method can be developed for other areas.
7. The method is very simple, and Fig. 12 may be used as a working chart for any area.

Nomenclature

D = depth, ft
D_i = equivalent depth of lowermost normally pressured formation, ft
K_i = matrix stress coefficient
p_w = wellbore pressure, psi
p = formation pressure, psi
S = overburden stress, psi
σ = net effective overburden stress, $\sigma = S - p$, psi
ν = Poisson's ratio

Acknowledgments

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References

1. Hubbert, M. King and Willis, D. G.: "Mechanics of Hydraulic Fracturing", *Trans.*, AIME (1957) **210**, 153-166.
2. Howard, G. C. and Scott, P. P.: "An Analysis and the Control of Lost Circulation", *Trans.*, AIME (1951) **192**, 171-182.
3. Matthews, W. R. and Kelly, John: "How to Predict Formation Pressure and Fracture Gradient", *Oil and Gas J.* (Feb. 20, 1967).
4. Goldsmith, R. and Wilson, G.: staff engineers, Production Engineering Services, Continental Oil Co., Houston, Tex., private communication.
5. Costley, R. D.: "Hazards and Costs Cut by Planned Drilling Programs", *World Oil* (Oct., 1967) 92.
6. Crittendon, B. C.: "The Mechanics of Design and Interpretation of Hydraulic Fracture Treatments", *J. Pet. Tech.* (Oct., 1959) 21-29.
7. Wuerker, R. G.: "Annotated Tables of Strength and Properties of Rocks", *Drilling*, SPE Petroleum Transactions Reprint Series No. 6 (1963) 23-45.
8. Hottman, C. E. and Johnson, R. K.: "Estimation of Formation Pressures from Log-Derived Shale Properties", *J. Pet. Tech.* (June, 1965) 717-722. **JPT**

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APPENDIX

VII-7 Predict W Theory

APPENDIX VII-7

Mathematical Basis of Equations Used in Modeling Pressure Buildup

The following discussion reviews the mathematical and physical basis of determining reservoir pressure buildup. The model presented is based on the line source solution to the radial diffusivity equation for pressure behavior in a homogeneous reservoir. The model was implemented using the Visual Basic program PredictW.

Exponential-Integral Formulation

The pressure response for radial flow of a slightly compressible fluid in a planar (porous) injection layer with spatially-constant properties is determined by the well known diffusivity equation (Lee, 1982):

$$\frac{\partial^2 p}{\partial r^2} + \frac{1}{r}\frac{\partial p}{\partial r} = \frac{\phi \mu c_t}{0.000264\ k}\frac{\partial p}{\partial t} \qquad \text{Equation 1}$$

where ϕ, μ, c_t, and k refer to porosity, viscosity (cp), compressibility (psi^{-1}), and permeability (md), respectively. The pressure, p, is expressed in psi; radial distance, r, is in feet; and time, t, is indicated in days. For an infinite reservoir of thickness h (ft) with $p \rightarrow p_o$ (initial pressure) as $r \rightarrow \infty$, the transient pressure, p (r, t), for a single line source injector at r = 0 is determined from Equation 1 as (Muskat, 1982):

$$p(r,t) = p_o - \frac{70.6 q\mu}{kh} Ei\left(\frac{-39.5\phi\mu c_t r^2}{kt}\right), \qquad \text{Equation 2}$$

where Ei represents the exponential integral defined by:

$$Ei(-x) = -\int_x^\infty \frac{e^{-\varepsilon}}{\varepsilon}\, d\varepsilon \qquad \text{Equation 3}$$

and q represents the (constant) injection rate in barrels per day.

For the general case of multiple wells in a single layer, in which injection from each is represented by a succession of piece-wise constant flow rate intervals, the pressure response is readily obtained by superposition of elementary solutions given by Equation 2. In terms of Cartesian coordinates, the pressure transient at an arbitrary point (x, y) at time "t" is given by:

$$p(x,y,t) = p_o + \sum_{j=1}^{N} \frac{70.6 q_1^j \mu}{kh} \mathrm{Ei}\left(\frac{-39.5\phi\mu c_t[(x-x_j)^2 + (y-y_j)^2]}{kt} \right)$$
$$+ \sum_{j=1}^{N} \sum_{i=1}^{n_{j-1}} 70.6[(q_{i-1}^j - q_i^j)\mu / kh] \, \mathrm{Ei}\left(\frac{-39.5\phi\mu c_t[(x-x_j)^2 + (y-y_j)^2]}{k(t-t_i^j)} \right)$$

Equation 4

for all $t_i^j < t$. In Equation 4, the following notation is employed:

N	=	number of wells injecting into the reservoir
n_j	=	number of constant flow rate increments for well j operative over time t
i	=	flow rate summation index ($1 < i < n_j$)
j	=	well number summation index ($1 < j < N$)
t_i	=	cumulative time corresponding to the end of injection rate interval i for well j
x_j, y_j	=	cartesian coordinates of well j
q_i^j	=	flow rate from well j during flow increment i

Equation 4 forms the basis for determining the COI for a general multi-well system.

To determine shutin or flowing pressures at a generic wellbore location, Equation 4 is modified to include a dimensionless skin factor, s_b, which reflects the effects of altered properties in the near-wellbore region (Van Everdingen, 1953). The associated augmentation, Δp_{skin}^b, of the theoretical flowing pressure is assumed to be of the form:

$$\Delta p^{b}_{skin}\ (psi) = 141.2\ \frac{q^{b}_{i}\,\mu}{kh} s_b \qquad \text{Equation 5}$$

Incorporation of Equation 5 into Equation 4 and replacement of the quantity $[(x-x_b)^2 + (y-y_b)^2]$ in the Ei-function argument by $r^2_{w,b}$ (wellbore radius squared) leads to the following expression for the transient flowing pressure at a generic wellbore (b):

$$\begin{aligned} p^{b}_{wf}\left(x_b, y_b, t\right) = p_o &+ \sum_{j=1}^{N} \frac{70.6 q^{j}_{1}\mu}{kh} \mathrm{Ei}\left(\frac{-39.5\phi\mu c_t[(x_b - x_j)^2 + (y_b - y_j)^2]}{kt} \right) \\ &+ \sum_{j=1(j\neq b)}^{N} \sum_{i=1}^{n_{j-1}} \frac{70.6(q^{j}_{i+1} - q^{j}_{i})\mu}{kh} \mathrm{Ei}\left(\frac{-39.5\phi\mu c_t[x_b - x_j)^2 + (y_b - y_j)^2]}{k(t - t^{j}_{i})} \right) \\ &+ \frac{70.6 q^{b}_{1}\mu}{kh} \left[\mathrm{Ei}\left(\frac{-39.5\phi\mu c_t r^2_{w,b}}{kt} \right) - 2s_b \right] \\ &+ \sum_{i=1}^{n_{j-1}} \frac{70.6(q^{b}_{i+1} - q^{b}_{i})\mu}{kh} \left[\mathrm{Ei}\left(\frac{-39.5\phi\mu c_t r^2_{w,b}}{k(t - t^{b}_{i})} \right) - 2s_b \right] \end{aligned}$$

Equation 6

where x_b, y_b denote the wellbore coordinates at well b where the pressure response is evaluated.

Application of Equations 4 and 6 to address actual operational conditions often requires inclusion of many wells (including image injectors), each having several hundred flow rate increments. Accordingly, a Visual Basic computer program, PredictW, was created to evaluate these equations. The exponential integral is determined utilizing numerical methods (Abramowitz and Stegun, 1972). When isobaric contours at a given time in a given injection zone (unit) are desired, then Equation 4, actually $p - p_o$, is evaluated at each node of a predefined uniform grid. The resulting Δp-x-y array is then plotted to visualize the COI using Surfer (®Golden Software, Inc.). When the transient wellbore response is desired, Equation 6 is utilized by PredictW. The output in this case consists of a record of $\Delta p = p - p_o$ at a single well location over a specified time interval.

TECHNICAL REFERENCES

Lee, J., Well Testing, SPE Textbook Series, Vol. 1., Dallas, TX, 1982.

Muskat, M., The Flow of Homogeneous Fluids Through Porous Media, International Human Resources Development Corporation, 2nd Ed., Boston, 1982.

Van Everdingen, A.F., "The Skin Effect and its Influence on the Productive Capacity of a Well," Transactions, AIME, 1953.

Abramowitz, M., and Stegun, I.A., Handbook of Mathematical Functions, Dover, New York, 1972.

APPENDIX

VII-8 Predict W Modeling Input and Output

APPENDIX VII-8
Predict W Modeling Input and Output

Predict W Input

[Version]

2

[Project Description]

Itasca Facility: IW-1

Project Number: 192128M

30 Year Non-Transmissive Fault

[Formation]

Permeability = 100

Thickness = 150

Porosity = 0.09

Initial Pressure = 0

Datum Depth = 0

Datum KB = 0

Datum GL = 0

Datum FL = 0

[Fluid]

Viscosity = 0.321

Total Compressibility = 7.92E-06

Formation Volume Factor = 1

[Wells]

NumWells = 1

Active Well = iw-1

well1 = iw-1

[Grid Output]

0,0,0,0,0,0,0,10957.9

0,0,0,0,0,0,0,3653

```
    0,0,0,0,0,0,0,366
[Well]
    WellName = iw-1
    ActiveRowRates = 2
    ActiveRowPressures = 2
    ActiveRowTimes = 1
    ActiveRowImages = 1
    ActiveTab = 1
    DatumDepth = 0
    PinitDatum = 0
    Pcal = 0
    WBRadius = 0.583
    WellStorage = 0
    WellSkin = 0
    WellLocX = 2121346.08
    WellLocY = 192013.07
    WellRateFraction = 1
    RunWBsolution = -1
    RunNearWellsolution = -1
    NearWellDistance = 20000
    NearWellgrdX = 100
    NearWellgrdY = 100
    UseImageWells = True
  Image_Wells
    2126965.291,184575.049,1
  End_Image_Wells
  Output_Times
    20240101000000,20600101000000,0,1
  End_Output_Times
  Hist_Pres_Meas
```

```
  0, 0, 0, 0
End_Hist_Pres_Meas
Rates
'  ET (days), rate(gpm), date:yyyymmddhhmmss
  0, 0, 20240101000000
  10958, -102, 20540101000000
  1, 0, 20540102000000
End_Rates
```

Predict W Output

[Wellbore Pressure Output],,

WellName = iw-1,,

Date_Time,SimTime,SimDeltaPressure

mm/dd/yyyy_hh:mm:ss,days,psi

1/1/2024 0:00	0	0
1/2/2024 0:00	1	85.4991
1/3/2024 0:00	2	89.0604
1/4/2024 0:00	3	91.227
1/5/2024 0:00	4	92.8607
1/6/2024 0:00	5	94.2087
1/7/2024 0:00	6	95.3721
1/8/2024 0:00	7	96.4027
1/9/2024 0:00	8	97.3314
1/10/2024 0:00	9	98.1782
1/11/2024 0:00	10	98.9575
1/12/2024 0:00	11	99.6798
1/13/2024 0:00	12	100.3532
1/14/2024 0:00	13	100.9841
1/15/2024 0:00	14	101.5777
1/16/2024 0:00	15	102.1383
1/17/2024 0:00	16	102.6695
1/18/2024 0:00	17	103.1741
1/19/2024 0:00	18	103.6548
1/20/2024 0:00	19	104.1137
1/21/2024 0:00	20	104.5528
1/22/2024 0:00	21	104.9737
1/23/2024 0:00	22	105.3779
1/24/2024 0:00	23	105.7666
1/25/2024 0:00	24	106.141
1/26/2024 0:00	25	106.5021
1/27/2024 0:00	26	106.8509
1/28/2024 0:00	27	107.1881
1/29/2024 0:00	28	107.5145
1/30/2024 0:00	29	107.8307
1/31/2024 0:00	30	108.1375
2/1/2024 0:00	31	108.4353
2/2/2024 0:00	32	108.7246
2/3/2024 0:00	33	109.0059
2/4/2024 0:00	34	109.2797
2/5/2024 0:00	35	109.5464
2/6/2024 0:00	36	109.8062
2/7/2024 0:00	37	110.0596
2/8/2024 0:00	38	110.3068
2/9/2024 0:00	39	110.5482
2/10/2024 0:00	40	110.784
2/11/2024 0:00	41	111.0144
2/12/2024 0:00	42	111.2398
2/13/2024 0:00	43	111.4603
2/14/2024 0:00	44	111.6762
2/15/2024 0:00	45	111.8875
2/16/2024 0:00	46	112.0946
2/17/2024 0:00	47	112.2976
2/18/2024 0:00	48	112.4966
2/19/2024 0:00	49	112.6918
2/20/2024 0:00	50	112.8833
2/21/2024 0:00	51	113.0713
2/22/2024 0:00	52	113.2559
2/23/2024 0:00	53	113.4372
2/24/2024 0:00	54	113.6153
2/25/2024 0:00	55	113.7904
2/26/2024 0:00	56	113.9626
2/27/2024 0:00	57	114.1318
2/28/2024 0:00	58	114.2984
2/29/2024 0:00	59	114.4622
3/1/2024 0:00	60	114.6235
3/2/2024 0:00	61	114.7822
3/3/2024 0:00	62	114.9385
3/4/2024 0:00	63	115.0925
3/5/2024 0:00	64	115.2441
3/6/2024 0:00	65	115.3936
3/7/2024 0:00	66	115.5409
3/8/2024 0:00	67	115.6861
3/9/2024 0:00	68	115.8292
3/10/2024 0:00	69	115.9704
3/11/2024 0:00	70	116.1096
3/12/2024 0:00	71	116.247
3/13/2024 0:00	72	116.3826
3/14/2024 0:00	73	116.5163
3/15/2024 0:00	74	116.6484
3/16/2024 0:00	75	116.7787
3/17/2024 0:00	76	116.9074
3/18/2024 0:00	77	117.0345
3/19/2024 0:00	78	117.1601
3/20/2024 0:00	79	117.2841
3/21/2024 0:00	80	117.4066
3/22/2024 0:00	81	117.5277
3/23/2024 0:00	82	117.6474
3/24/2024 0:00	83	117.7656
3/25/2024 0:00	84	117.8825
3/26/2024 0:00	85	117.9981
3/27/2024 0:00	86	118.1124
3/28/2024 0:00	87	118.2254
3/29/2024 0:00	88	118.3372
3/30/2024 0:00	89	118.4478
3/31/2024 0:00	90	118.5572
4/1/2024 0:00	91	118.6654
4/2/2024 0:00	92	118.7725
4/3/2024 0:00	93	118.8785
4/4/2024 0:00	94	118.9834
4/5/2024 0:00	95	119.0872
4/6/2024 0:00	96	119.19
4/7/2024 0:00	97	119.2918
4/8/2024 0:00	98	119.3925
4/9/2024 0:00	99	119.4923
4/10/2024 0:00	100	119.5911
4/11/2024 0:00	101	119.6889
4/12/2024 0:00	102	119.7859
4/13/2024 0:00	103	119.8819
4/14/2024 0:00	104	119.977
4/15/2024 0:00	105	120.0712
4/16/2024 0:00	106	120.1646
4/17/2024 0:00	107	120.2571
4/18/2024 0:00	108	120.3488
4/19/2024 0:00	109	120.4397
4/20/2024 0:00	110	120.5298
4/21/2024 0:00	111	120.6191
4/22/2024 0:00	112	120.7076
4/23/2024 0:00	113	120.7954
4/24/2024 0:00	114	120.8824
4/25/2024 0:00	115	120.9687
4/26/2024 0:00	116	121.0542
4/27/2024 0:00	117	121.139
4/28/2024 0:00	118	121.2232
4/29/2024 0:00	119	121.3066
4/30/2024 0:00	120	121.3894
5/1/2024 0:00	121	121.4715
5/2/2024 0:00	122	121.553
5/3/2024 0:00	123	121.6338
5/4/2024 0:00	124	121.7139
5/5/2024 0:00	125	121.7935
5/6/2024 0:00	126	121.8724
5/7/2024 0:00	127	121.9507
5/8/2024 0:00	128	122.0285
5/9/2024 0:00	129	122.1056
5/10/2024 0:00	130	122.1822
5/11/2024 0:00	131	122.2582
5/12/2024 0:00	132	122.3336
5/13/2024 0:00	133	122.4085
5/14/2024 0:00	134	122.4828
5/15/2024 0:00	135	122.5566
5/16/2024 0:00	136	122.6299
5/17/2024 0:00	137	122.7026
5/18/2024 0:00	138	122.7748
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5/20/2024 0:00	140	122.9178
5/21/2024 0:00	141	122.9885
5/22/2024 0:00	142	123.0587
5/23/2024 0:00	143	123.1285
5/24/2024 0:00	144	123.1978
5/25/2024 0:00	145	123.2666
5/26/2024 0:00	146	123.335
5/27/2024 0:00	147	123.4029
5/28/2024 0:00	148	123.4703
5/29/2024 0:00	149	123.5373
5/30/2024 0:00	150	123.6039
5/31/2024 0:00	151	123.67
6/1/2024 0:00	152	123.7358
6/2/2024 0:00	153	123.8011
6/3/2024 0:00	154	123.8659
6/4/2024 0:00	155	123.9304
6/5/2024 0:00	156	123.9945
6/6/2024 0:00	157	124.0581
6/7/2024 0:00	158	124.1214
6/8/2024 0:00	159	124.1843
6/9/2024 0:00	160	124.2468
6/10/2024 0:00	161	124.3089
6/11/2024 0:00	162	124.3706
6/12/2024 0:00	163	124.432
6/13/2024 0:00	164	124.493
6/14/2024 0:00	165	124.5537
6/15/2024 0:00	166	124.6139
6/16/2024 0:00	167	124.6739
6/17/2024 0:00	168	124.7334
6/18/2024 0:00	169	124.7927
6/19/2024 0:00	170	124.8516
6/20/2024 0:00	171	124.9101

6/21/2024 0:00	172	124.9683	8/6/2024 0:00	218	127.3404	9/21/2024 0:00	264	129.2638	11/6/2024 0:00	310	130.8815
6/22/2024 0:00	173	125.0262	8/7/2024 0:00	219	127.3863	9/22/2024 0:00	265	129.3018	11/7/2024 0:00	311	130.914
6/23/2024 0:00	174	125.0838	8/8/2024 0:00	220	127.432	9/23/2024 0:00	266	129.3397	11/8/2024 0:00	312	130.9463
6/24/2024 0:00	175	125.141	8/9/2024 0:00	221	127.4775	9/24/2024 0:00	267	129.3775	11/9/2024 0:00	313	130.9786
6/25/2024 0:00	176	125.1979	8/10/2024 0:00	222	127.5228	9/25/2024 0:00	268	129.4151	11/10/2024 0:00	314	131.0107
6/26/2024 0:00	177	125.2545	8/11/2024 0:00	223	127.5679	9/26/2024 0:00	269	129.4526	11/11/2024 0:00	315	131.0428
6/27/2024 0:00	178	125.3108	8/12/2024 0:00	224	127.6128	9/27/2024 0:00	270	129.4899	11/12/2024 0:00	316	131.0748
6/28/2024 0:00	179	125.3668	8/13/2024 0:00	225	127.6575	9/28/2024 0:00	271	129.5271	11/13/2024 0:00	317	131.1066
6/29/2024 0:00	180	125.4225	8/14/2024 0:00	226	127.702	9/29/2024 0:00	272	129.5642	11/14/2024 0:00	318	131.1384
6/30/2024 0:00	181	125.4779	8/15/2024 0:00	227	127.7463	9/30/2024 0:00	273	129.6011	11/15/2024 0:00	319	131.1701
7/1/2024 0:00	182	125.533	8/16/2024 0:00	228	127.7905	10/1/2024 0:00	274	129.6379	11/16/2024 0:00	320	131.2016
7/2/2024 0:00	183	125.5877	8/17/2024 0:00	229	127.8344	10/2/2024 0:00	275	129.6746	11/17/2024 0:00	321	131.2331
7/3/2024 0:00	184	125.6422	8/18/2024 0:00	230	127.8781	10/3/2024 0:00	276	129.7111	11/18/2024 0:00	322	131.2645
7/4/2024 0:00	185	125.6964	8/19/2024 0:00	231	127.9217	10/4/2024 0:00	277	129.7475	11/19/2024 0:00	323	131.2957
7/5/2024 0:00	186	125.7503	8/20/2024 0:00	232	127.9651	10/5/2024 0:00	278	129.7838	11/20/2024 0:00	324	131.3269
7/6/2024 0:00	187	125.804	8/21/2024 0:00	233	128.0082	10/6/2024 0:00	279	129.82	11/21/2024 0:00	325	131.358
7/7/2024 0:00	188	125.8573	8/22/2024 0:00	234	128.0513	10/7/2024 0:00	280	129.856	11/22/2024 0:00	326	131.389
7/8/2024 0:00	189	125.9104	8/23/2024 0:00	235	128.0941	10/8/2024 0:00	281	129.8919	11/23/2024 0:00	327	131.4199
7/9/2024 0:00	190	125.9632	8/24/2024 0:00	236	128.1367	10/9/2024 0:00	282	129.9277	11/24/2024 0:00	328	131.4507
7/10/2024 0:00	191	126.0157	8/25/2024 0:00	237	128.1792	10/10/2024 0:00	283	129.9633	11/25/2024 0:00	329	131.4814
7/11/2024 0:00	192	126.068	8/26/2024 0:00	238	128.2215	10/11/2024 0:00	284	129.9988	11/26/2024 0:00	330	131.512
7/12/2024 0:00	193	126.1199	8/27/2024 0:00	239	128.2636	10/12/2024 0:00	285	130.0342	11/27/2024 0:00	331	131.5426
7/13/2024 0:00	194	126.1717	8/28/2024 0:00	240	128.3056	10/13/2024 0:00	286	130.0695	11/28/2024 0:00	332	131.573
7/14/2024 0:00	195	126.2231	8/29/2024 0:00	241	128.3473	10/14/2024 0:00	287	130.1046	11/29/2024 0:00	333	131.6033
7/15/2024 0:00	196	126.2743	8/30/2024 0:00	242	128.3889	10/15/2024 0:00	288	130.1397	11/30/2024 0:00	334	131.6336
7/16/2024 0:00	197	126.3253	8/31/2024 0:00	243	128.4304	10/16/2024 0:00	289	130.1746	12/1/2024 0:00	335	131.6638
7/17/2024 0:00	198	126.376	9/1/2024 0:00	244	128.4716	10/17/2024 0:00	290	130.2094	12/2/2024 0:00	336	131.6938
7/18/2024 0:00	199	126.4264	9/2/2024 0:00	245	128.5127	10/18/2024 0:00	291	130.2441	12/3/2024 0:00	337	131.7238
7/19/2024 0:00	200	126.4766	9/3/2024 0:00	246	128.5537	10/19/2024 0:00	292	130.2786	12/4/2024 0:00	338	131.7537
7/20/2024 0:00	201	126.5266	9/4/2024 0:00	247	128.5944	10/20/2024 0:00	293	130.3131	12/5/2024 0:00	339	131.7836
7/21/2024 0:00	202	126.5763	9/5/2024 0:00	248	128.6351	10/21/2024 0:00	294	130.3474	12/6/2024 0:00	340	131.8133
7/22/2024 0:00	203	126.6258	9/6/2024 0:00	249	128.6755	10/22/2024 0:00	295	130.3816	12/7/2024 0:00	341	131.8429
7/23/2024 0:00	204	126.675	9/7/2024 0:00	250	128.7158	10/23/2024 0:00	296	130.4157	12/8/2024 0:00	342	131.8725
7/24/2024 0:00	205	126.724	9/8/2024 0:00	251	128.7559	10/24/2024 0:00	297	130.4497	12/9/2024 0:00	343	131.9019
7/25/2024 0:00	206	126.7728	9/9/2024 0:00	252	128.7959	10/25/2024 0:00	298	130.4836	12/10/2024 0:00	344	131.9313
7/26/2024 0:00	207	126.8213	9/10/2024 0:00	253	128.8357	10/26/2024 0:00	299	130.5173	12/11/2024 0:00	345	131.9606
7/27/2024 0:00	208	126.8696	9/11/2024 0:00	254	128.8754	10/27/2024 0:00	300	130.551	12/12/2024 0:00	346	131.9898
7/28/2024 0:00	209	126.9177	9/12/2024 0:00	255	128.9149	10/28/2024 0:00	301	130.5845	12/13/2024 0:00	347	132.019
7/29/2024 0:00	210	126.9655	9/13/2024 0:00	256	128.9543	10/29/2024 0:00	302	130.6179	12/14/2024 0:00	348	132.048
7/30/2024 0:00	211	127.0131	9/14/2024 0:00	257	128.9935	10/30/2024 0:00	303	130.6513	12/15/2024 0:00	349	132.077
7/31/2024 0:00	212	127.0605	9/15/2024 0:00	258	129.0325	10/31/2024 0:00	304	130.6845	12/16/2024 0:00	350	132.1059
8/1/2024 0:00	213	127.1077	9/16/2024 0:00	259	129.0714	11/1/2024 0:00	305	130.7176	12/17/2024 0:00	351	132.1347
8/2/2024 0:00	214	127.1547	9/17/2024 0:00	260	129.1102	11/2/2024 0:00	306	130.7506	12/18/2024 0:00	352	132.1634
8/3/2024 0:00	215	127.2014	9/18/2024 0:00	261	129.1488	11/3/2024 0:00	307	130.7834	12/19/2024 0:00	353	132.1921
8/4/2024 0:00	216	127.248	9/19/2024 0:00	262	129.1873	11/4/2024 0:00	308	130.8162	12/20/2024 0:00	354	132.2206
8/5/2024 0:00	217	127.2943	9/20/2024 0:00	263	129.2256	11/5/2024 0:00	309	130.8489	12/21/2024 0:00	355	132.2491

12/22/2024 0:00	356	132.2775	2/6/2025 0:00	402	133.5053	3/24/2025 0:00	448	134.6012	5/9/2025 0:00	494	135.5907
12/23/2024 0:00	357	132.3058	2/7/2025 0:00	403	133.5304	3/25/2025 0:00	449	134.6237	5/10/2025 0:00	495	135.6111
12/24/2024 0:00	358	132.3341	2/8/2025 0:00	404	133.5555	3/26/2025 0:00	450	134.6462	5/11/2025 0:00	496	135.6316
12/25/2024 0:00	359	132.3622	2/9/2025 0:00	405	133.5805	3/27/2025 0:00	451	134.6687	5/12/2025 0:00	497	135.652
12/26/2024 0:00	360	132.3903	2/10/2025 0:00	406	133.6054	3/28/2025 0:00	452	134.6911	5/13/2025 0:00	498	135.6723
12/27/2024 0:00	361	132.4183	2/11/2025 0:00	407	133.6303	3/29/2025 0:00	453	134.7135	5/14/2025 0:00	499	135.6926
12/28/2024 0:00	362	132.4463	2/12/2025 0:00	408	133.6551	3/30/2025 0:00	454	134.7358	5/15/2025 0:00	500	135.7129
12/29/2024 0:00	363	132.4741	2/13/2025 0:00	409	133.6799	3/31/2025 0:00	455	134.7581	5/16/2025 0:00	501	135.7332
12/30/2024 0:00	364	132.5019	2/14/2025 0:00	410	133.7046	4/1/2025 0:00	456	134.7803	5/17/2025 0:00	502	135.7534
12/31/2024 0:00	365	132.5296	2/15/2025 0:00	411	133.7292	4/2/2025 0:00	457	134.8025	5/18/2025 0:00	503	135.7735
1/1/2025 0:00	366	132.5573	2/16/2025 0:00	412	133.7538	4/3/2025 0:00	458	134.8246	5/19/2025 0:00	504	135.7936
1/2/2025 0:00	367	132.5848	2/17/2025 0:00	413	133.7783	4/4/2025 0:00	459	134.8467	5/20/2025 0:00	505	135.8137
1/3/2025 0:00	368	132.6123	2/18/2025 0:00	414	133.8027	4/5/2025 0:00	460	134.8687	5/21/2025 0:00	506	135.8337
1/4/2025 0:00	369	132.6397	2/19/2025 0:00	415	133.8271	4/6/2025 0:00	461	134.8907	5/22/2025 0:00	507	135.8537
1/5/2025 0:00	370	132.6671	2/20/2025 0:00	416	133.8515	4/7/2025 0:00	462	134.9126	5/23/2025 0:00	508	135.8737
1/6/2025 0:00	371	132.6943	2/21/2025 0:00	417	133.8758	4/8/2025 0:00	463	134.9345	5/24/2025 0:00	509	135.8936
1/7/2025 0:00	372	132.7215	2/22/2025 0:00	418	133.9	4/9/2025 0:00	464	134.9563	5/25/2025 0:00	510	135.9135
1/8/2025 0:00	373	132.7486	2/23/2025 0:00	419	133.9241	4/10/2025 0:00	465	134.9781	5/26/2025 0:00	511	135.9334
1/9/2025 0:00	374	132.7757	2/24/2025 0:00	420	133.9482	4/11/2025 0:00	466	134.9999	5/27/2025 0:00	512	135.9532
1/10/2025 0:00	375	132.8027	2/25/2025 0:00	421	133.9723	4/12/2025 0:00	467	135.0216	5/28/2025 0:00	513	135.9729
1/11/2025 0:00	376	132.8296	2/26/2025 0:00	422	133.9963	4/13/2025 0:00	468	135.0432	5/29/2025 0:00	514	135.9927
1/12/2025 0:00	377	132.8564	2/27/2025 0:00	423	134.0202	4/14/2025 0:00	469	135.0648	5/30/2025 0:00	515	136.0123
1/13/2025 0:00	378	132.8832	2/28/2025 0:00	424	134.0441	4/15/2025 0:00	470	135.0864	5/31/2025 0:00	516	136.032
1/14/2025 0:00	379	132.9099	3/1/2025 0:00	425	134.0679	4/16/2025 0:00	471	135.1079	6/1/2025 0:00	517	136.0516
1/15/2025 0:00	380	132.9365	3/2/2025 0:00	426	134.0917	4/17/2025 0:00	472	135.1294	6/2/2025 0:00	518	136.0712
1/16/2025 0:00	381	132.963	3/3/2025 0:00	427	134.1154	4/18/2025 0:00	473	135.1508	6/3/2025 0:00	519	136.0907
1/17/2025 0:00	382	132.9895	3/4/2025 0:00	428	134.1391	4/19/2025 0:00	474	135.1722	6/4/2025 0:00	520	136.1102
1/18/2025 0:00	383	133.016	3/5/2025 0:00	429	134.1627	4/20/2025 0:00	475	135.1935	6/5/2025 0:00	521	136.1297
1/19/2025 0:00	384	133.0423	3/6/2025 0:00	430	134.1863	4/21/2025 0:00	476	135.2148	6/6/2025 0:00	522	136.1491
1/20/2025 0:00	385	133.0686	3/7/2025 0:00	431	134.2098	4/22/2025 0:00	477	135.2361	6/7/2025 0:00	523	136.1685
1/21/2025 0:00	386	133.0948	3/8/2025 0:00	432	134.2332	4/23/2025 0:00	478	135.2573	6/8/2025 0:00	524	136.1879
1/22/2025 0:00	387	133.1209	3/9/2025 0:00	433	134.2566	4/24/2025 0:00	479	135.2784	6/9/2025 0:00	525	136.2072
1/23/2025 0:00	388	133.147	3/10/2025 0:00	434	134.2799	4/25/2025 0:00	480	135.2995	6/10/2025 0:00	526	136.2265
1/24/2025 0:00	389	133.173	3/11/2025 0:00	435	134.3032	4/26/2025 0:00	481	135.3206	6/11/2025 0:00	527	136.2457
1/25/2025 0:00	390	133.199	3/12/2025 0:00	436	134.3264	4/27/2025 0:00	482	135.3416	6/12/2025 0:00	528	136.2649
1/26/2025 0:00	391	133.2249	3/13/2025 0:00	437	134.3496	4/28/2025 0:00	483	135.3626	6/13/2025 0:00	529	136.2841
1/27/2025 0:00	392	133.2507	3/14/2025 0:00	438	134.3727	4/29/2025 0:00	484	135.3836	6/14/2025 0:00	530	136.3032
1/28/2025 0:00	393	133.2764	3/15/2025 0:00	439	134.3958	4/30/2025 0:00	485	135.4045	6/15/2025 0:00	531	136.3223
1/29/2025 0:00	394	133.3021	3/16/2025 0:00	440	134.4188	5/1/2025 0:00	486	135.4253	6/16/2025 0:00	532	136.3414
1/30/2025 0:00	395	133.3277	3/17/2025 0:00	441	134.4418	5/2/2025 0:00	487	135.4461	6/17/2025 0:00	533	136.3604
1/31/2025 0:00	396	133.3533	3/18/2025 0:00	442	134.4647	5/3/2025 0:00	488	135.4669	6/18/2025 0:00	534	136.3794
2/1/2025 0:00	397	133.3788	3/19/2025 0:00	443	134.4876	5/4/2025 0:00	489	135.4876	6/19/2025 0:00	535	136.3984
2/2/2025 0:00	398	133.4042	3/20/2025 0:00	444	134.5104	5/5/2025 0:00	490	135.5083	6/20/2025 0:00	536	136.4173
2/3/2025 0:00	399	133.4296	3/21/2025 0:00	445	134.5332	5/6/2025 0:00	491	135.529	6/21/2025 0:00	537	136.4362
2/4/2025 0:00	400	133.4549	3/22/2025 0:00	446	134.5559	5/7/2025 0:00	492	135.5496	6/22/2025 0:00	538	136.455
2/5/2025 0:00	401	133.4801	3/23/2025 0:00	447	134.5786	5/8/2025 0:00	493	135.5701	6/23/2025 0:00	539	136.4738

6/24/2025 0:00	540	136.4926	8/9/2025 0:00	586	137.3213	9/24/2025 0:00	632	138.0877	11/9/2025 0:00	678	138.8006
6/25/2025 0:00	541	136.5114	8/10/2025 0:00	587	137.3386	9/25/2025 0:00	633	138.1038	11/10/2025 0:00	679	138.8156
6/26/2025 0:00	542	136.5301	8/11/2025 0:00	588	137.3559	9/26/2025 0:00	634	138.1198	11/11/2025 0:00	680	138.8305
6/27/2025 0:00	543	136.5488	8/12/2025 0:00	589	137.3731	9/27/2025 0:00	635	138.1358	11/12/2025 0:00	681	138.8454
6/28/2025 0:00	544	136.5674	8/13/2025 0:00	590	137.3903	9/28/2025 0:00	636	138.1517	11/13/2025 0:00	682	138.8603
6/29/2025 0:00	545	136.586	8/14/2025 0:00	591	137.4075	9/29/2025 0:00	637	138.1677	11/14/2025 0:00	683	138.8752
6/30/2025 0:00	546	136.6046	8/15/2025 0:00	592	137.4246	9/30/2025 0:00	638	138.1836	11/15/2025 0:00	684	138.89
7/1/2025 0:00	547	136.6232	8/16/2025 0:00	593	137.4417	10/1/2025 0:00	639	138.1995	11/16/2025 0:00	685	138.9048
7/2/2025 0:00	548	136.6417	8/17/2025 0:00	594	137.4588	10/2/2025 0:00	640	138.2153	11/17/2025 0:00	686	138.9196
7/3/2025 0:00	549	136.6601	8/18/2025 0:00	595	137.4759	10/3/2025 0:00	641	138.2312	11/18/2025 0:00	687	138.9344
7/4/2025 0:00	550	136.6786	8/19/2025 0:00	596	137.4929	10/4/2025 0:00	642	138.247	11/19/2025 0:00	688	138.9492
7/5/2025 0:00	551	136.697	8/20/2025 0:00	597	137.5099	10/5/2025 0:00	643	138.2628	11/20/2025 0:00	689	138.9639
7/6/2025 0:00	552	136.7154	8/21/2025 0:00	598	137.5269	10/6/2025 0:00	644	138.2786	11/21/2025 0:00	690	138.9787
7/7/2025 0:00	553	136.7337	8/22/2025 0:00	599	137.5438	10/7/2025 0:00	645	138.2943	11/22/2025 0:00	691	138.9934
7/8/2025 0:00	554	136.752	8/23/2025 0:00	600	137.5607	10/8/2025 0:00	646	138.31	11/23/2025 0:00	692	139.008
7/9/2025 0:00	555	136.7703	8/24/2025 0:00	601	137.5776	10/9/2025 0:00	647	138.3257	11/24/2025 0:00	693	139.0227
7/10/2025 0:00	556	136.7886	8/25/2025 0:00	602	137.5945	10/10/2025 0:00	648	138.3414	11/25/2025 0:00	694	139.0373
7/11/2025 0:00	557	136.8068	8/26/2025 0:00	603	137.6113	10/11/2025 0:00	649	138.357	11/26/2025 0:00	695	139.0519
7/12/2025 0:00	558	136.825	8/27/2025 0:00	604	137.6281	10/12/2025 0:00	650	138.3726	11/27/2025 0:00	696	139.0665
7/13/2025 0:00	559	136.8431	8/28/2025 0:00	605	137.6449	10/13/2025 0:00	651	138.3882	11/28/2025 0:00	697	139.0811
7/14/2025 0:00	560	136.8612	8/29/2025 0:00	606	137.6616	10/14/2025 0:00	652	138.4038	11/29/2025 0:00	698	139.0957
7/15/2025 0:00	561	136.8793	8/30/2025 0:00	607	137.6784	10/15/2025 0:00	653	138.4194	11/30/2025 0:00	699	139.1102
7/16/2025 0:00	562	136.8974	8/31/2025 0:00	608	137.6951	10/16/2025 0:00	654	138.4349	12/1/2025 0:00	700	139.1247
7/17/2025 0:00	563	136.9154	9/1/2025 0:00	609	137.7117	10/17/2025 0:00	655	138.4504	12/2/2025 0:00	701	139.1392
7/18/2025 0:00	564	136.9334	9/2/2025 0:00	610	137.7284	10/18/2025 0:00	656	138.4659	12/3/2025 0:00	702	139.1537
7/19/2025 0:00	565	136.9513	9/3/2025 0:00	611	137.745	10/19/2025 0:00	657	138.4813	12/4/2025 0:00	703	139.1681
7/20/2025 0:00	566	136.9693	9/4/2025 0:00	612	137.7616	10/20/2025 0:00	658	138.4968	12/5/2025 0:00	704	139.1825
7/21/2025 0:00	567	136.9872	9/5/2025 0:00	613	137.7781	10/21/2025 0:00	659	138.5122	12/6/2025 0:00	705	139.1969
7/22/2025 0:00	568	137.005	9/6/2025 0:00	614	137.7947	10/22/2025 0:00	660	138.5276	12/7/2025 0:00	706	139.2113
7/23/2025 0:00	569	137.0228	9/7/2025 0:00	615	137.8112	10/23/2025 0:00	661	138.5429	12/8/2025 0:00	707	139.2257
7/24/2025 0:00	570	137.0406	9/8/2025 0:00	616	137.8276	10/24/2025 0:00	662	138.5583	12/9/2025 0:00	708	139.24
7/25/2025 0:00	571	137.0584	9/9/2025 0:00	617	137.8441	10/25/2025 0:00	663	138.5736	12/10/2025 0:00	709	139.2544
7/26/2025 0:00	572	137.0762	9/10/2025 0:00	618	137.8605	10/26/2025 0:00	664	138.5889	12/11/2025 0:00	710	139.2687
7/27/2025 0:00	573	137.0939	9/11/2025 0:00	619	137.8769	10/27/2025 0:00	665	138.6041	12/12/2025 0:00	711	139.283
7/28/2025 0:00	574	137.1115	9/12/2025 0:00	620	137.8933	10/28/2025 0:00	666	138.6194	12/13/2025 0:00	712	139.2972
7/29/2025 0:00	575	137.1292	9/13/2025 0:00	621	137.9096	10/29/2025 0:00	667	138.6346	12/14/2025 0:00	713	139.3115
7/30/2025 0:00	576	137.1468	9/14/2025 0:00	622	137.926	10/30/2025 0:00	668	138.6498	12/15/2025 0:00	714	139.3257
7/31/2025 0:00	577	137.1644	9/15/2025 0:00	623	137.9422	10/31/2025 0:00	669	138.665	12/16/2025 0:00	715	139.3399
8/1/2025 0:00	578	137.1819	9/16/2025 0:00	624	137.9585	11/1/2025 0:00	670	138.6801	12/17/2025 0:00	716	139.3541
8/2/2025 0:00	579	137.1995	9/17/2025 0:00	625	137.9748	11/2/2025 0:00	671	138.6953	12/18/2025 0:00	717	139.3683
8/3/2025 0:00	580	137.217	9/18/2025 0:00	626	137.991	11/3/2025 0:00	672	138.7104	12/19/2025 0:00	718	139.3824
8/4/2025 0:00	581	137.2344	9/19/2025 0:00	627	138.0072	11/4/2025 0:00	673	138.7255	12/20/2025 0:00	719	139.3965
8/5/2025 0:00	582	137.2519	9/20/2025 0:00	628	138.0233	11/5/2025 0:00	674	138.7406	12/21/2025 0:00	720	139.4107
8/6/2025 0:00	583	137.2693	9/21/2025 0:00	629	138.0395	11/6/2025 0:00	675	138.7556	12/22/2025 0:00	721	139.4247
8/7/2025 0:00	584	137.2867	9/22/2025 0:00	630	138.0556	11/7/2025 0:00	676	138.7706	12/23/2025 0:00	722	139.4388
8/8/2025 0:00	585	137.304	9/23/2025 0:00	631	138.0717	11/8/2025 0:00	677	138.7856	12/24/2025 0:00	723	139.4529

12/25/2025 0:00	724	139.4669	2/9/2026 0:00	770	140.0923	3/27/2026 0:00	816	140.6817	5/12/2026 0:00	862	141.2388
12/26/2025 0:00	725	139.4809	2/10/2026 0:00	771	140.1055	3/28/2026 0:00	817	140.6941	5/13/2026 0:00	863	141.2506
12/27/2025 0:00	726	139.4949	2/11/2026 0:00	772	140.1187	3/29/2026 0:00	818	140.7065	5/14/2026 0:00	864	141.2624
12/28/2025 0:00	727	139.5089	2/12/2026 0:00	773	140.1318	3/30/2026 0:00	819	140.7189	5/15/2026 0:00	865	141.2741
12/29/2025 0:00	728	139.5228	2/13/2026 0:00	774	140.145	3/31/2026 0:00	820	140.7313	5/16/2026 0:00	866	141.2858
12/30/2025 0:00	729	139.5368	2/14/2026 0:00	775	140.1581	4/1/2026 0:00	821	140.7437	5/17/2026 0:00	867	141.2976
12/31/2025 0:00	730	139.5507	2/15/2026 0:00	776	140.1712	4/2/2026 0:00	822	140.7561	5/18/2026 0:00	868	141.3093
1/1/2026 0:00	731	139.5646	2/16/2026 0:00	777	140.1843	4/3/2026 0:00	823	140.7684	5/19/2026 0:00	869	141.321
1/2/2026 0:00	732	139.5785	2/17/2026 0:00	778	140.1973	4/4/2026 0:00	824	140.7808	5/20/2026 0:00	870	141.3327
1/3/2026 0:00	733	139.5923	2/18/2026 0:00	779	140.2104	4/5/2026 0:00	825	140.7931	5/21/2026 0:00	871	141.3443
1/4/2026 0:00	734	139.6062	2/19/2026 0:00	780	140.2234	4/6/2026 0:00	826	140.8054	5/22/2026 0:00	872	141.356
1/5/2026 0:00	735	139.62	2/20/2026 0:00	781	140.2364	4/7/2026 0:00	827	140.8177	5/23/2026 0:00	873	141.3676
1/6/2026 0:00	736	139.6338	2/21/2026 0:00	782	140.2494	4/8/2026 0:00	828	140.83	5/24/2026 0:00	874	141.3793
1/7/2026 0:00	737	139.6476	2/22/2026 0:00	783	140.2624	4/9/2026 0:00	829	140.8422	5/25/2026 0:00	875	141.3909
1/8/2026 0:00	738	139.6613	2/23/2026 0:00	784	140.2753	4/10/2026 0:00	830	140.8545	5/26/2026 0:00	876	141.4025
1/9/2026 0:00	739	139.6751	2/24/2026 0:00	785	140.2883	4/11/2026 0:00	831	140.8667	5/27/2026 0:00	877	141.4141
1/10/2026 0:00	740	139.6888	2/25/2026 0:00	786	140.3012	4/12/2026 0:00	832	140.8789	5/28/2026 0:00	878	141.4257
1/11/2026 0:00	741	139.7025	2/26/2026 0:00	787	140.3141	4/13/2026 0:00	833	140.8911	5/29/2026 0:00	879	141.4372
1/12/2026 0:00	742	139.7162	2/27/2026 0:00	788	140.327	4/14/2026 0:00	834	140.9033	5/30/2026 0:00	880	141.4488
1/13/2026 0:00	743	139.7299	2/28/2026 0:00	789	140.3399	4/15/2026 0:00	835	140.9155	5/31/2026 0:00	881	141.4603
1/14/2026 0:00	744	139.7436	3/1/2026 0:00	790	140.3528	4/16/2026 0:00	836	140.9277	6/1/2026 0:00	882	141.4719
1/15/2026 0:00	745	139.7572	3/2/2026 0:00	791	140.3656	4/17/2026 0:00	837	140.9398	6/2/2026 0:00	883	141.4834
1/16/2026 0:00	746	139.7708	3/3/2026 0:00	792	140.3784	4/18/2026 0:00	838	140.9519	6/3/2026 0:00	884	141.4949
1/17/2026 0:00	747	139.7844	3/4/2026 0:00	793	140.3913	4/19/2026 0:00	839	140.964	6/4/2026 0:00	885	141.5064
1/18/2026 0:00	748	139.798	3/5/2026 0:00	794	140.4041	4/20/2026 0:00	840	140.9761	6/5/2026 0:00	886	141.5178
1/19/2026 0:00	749	139.8116	3/6/2026 0:00	795	140.4168	4/21/2026 0:00	841	140.9882	6/6/2026 0:00	887	141.5293
1/20/2026 0:00	750	139.8251	3/7/2026 0:00	796	140.4296	4/22/2026 0:00	842	141.0003	6/7/2026 0:00	888	141.5408
1/21/2026 0:00	751	139.8386	3/8/2026 0:00	797	140.4424	4/23/2026 0:00	843	141.0124	6/8/2026 0:00	889	141.5522
1/22/2026 0:00	752	139.8522	3/9/2026 0:00	798	140.4551	4/24/2026 0:00	844	141.0244	6/9/2026 0:00	890	141.5636
1/23/2026 0:00	753	139.8656	3/10/2026 0:00	799	140.4678	4/25/2026 0:00	845	141.0364	6/10/2026 0:00	891	141.575
1/24/2026 0:00	754	139.8791	3/11/2026 0:00	800	140.4805	4/26/2026 0:00	846	141.0485	6/11/2026 0:00	892	141.5864
1/25/2026 0:00	755	139.8926	3/12/2026 0:00	801	140.4932	4/27/2026 0:00	847	141.0605	6/12/2026 0:00	893	141.5978
1/26/2026 0:00	756	139.906	3/13/2026 0:00	802	140.5059	4/28/2026 0:00	848	141.0724	6/13/2026 0:00	894	141.6092
1/27/2026 0:00	757	139.9194	3/14/2026 0:00	803	140.5185	4/29/2026 0:00	849	141.0844	6/14/2026 0:00	895	141.6206
1/28/2026 0:00	758	139.9328	3/15/2026 0:00	804	140.5312	4/30/2026 0:00	850	141.0964	6/15/2026 0:00	896	141.6319
1/29/2026 0:00	759	139.9462	3/16/2026 0:00	805	140.5438	5/1/2026 0:00	851	141.1083	6/16/2026 0:00	897	141.6432
1/30/2026 0:00	760	139.9596	3/17/2026 0:00	806	140.5564	5/2/2026 0:00	852	141.1203	6/17/2026 0:00	898	141.6546
1/31/2026 0:00	761	139.973	3/18/2026 0:00	807	140.569	5/3/2026 0:00	853	141.1322	6/18/2026 0:00	899	141.6659
2/1/2026 0:00	762	139.9863	3/19/2026 0:00	808	140.5816	5/4/2026 0:00	854	141.1441	6/19/2026 0:00	900	141.6772
2/2/2026 0:00	763	139.9996	3/20/2026 0:00	809	140.5942	5/5/2026 0:00	855	141.156	6/20/2026 0:00	901	141.6885
2/3/2026 0:00	764	140.0129	3/21/2026 0:00	810	140.6067	5/6/2026 0:00	856	141.1678	6/21/2026 0:00	902	141.6997
2/4/2026 0:00	765	140.0262	3/22/2026 0:00	811	140.6192	5/7/2026 0:00	857	141.1797	6/22/2026 0:00	903	141.711
2/5/2026 0:00	766	140.0395	3/23/2026 0:00	812	140.6318	5/8/2026 0:00	858	141.1916	6/23/2026 0:00	904	141.7222
2/6/2026 0:00	767	140.0527	3/24/2026 0:00	813	140.6443	5/9/2026 0:00	859	141.2034	6/24/2026 0:00	905	141.7335
2/7/2026 0:00	768	140.0659	3/25/2026 0:00	814	140.6567	5/10/2026 0:00	860	141.2152	6/25/2026 0:00	906	141.7447
2/8/2026 0:00	769	140.0792	3/26/2026 0:00	815	140.6692	5/11/2026 0:00	861	141.227	6/26/2026 0:00	907	141.7559

6/27/2026 0:00	908	141.7671	8/12/2026 0:00	954	142.2694	9/27/2026 0:00	1000	142.7481	11/12/2026 0:00	1046	143.2054
6/28/2026 0:00	909	141.7783	8/13/2026 0:00	955	142.28	9/28/2026 0:00	1001	142.7583	11/13/2026 0:00	1047	143.2151
6/29/2026 0:00	910	141.7895	8/14/2026 0:00	956	142.2907	9/29/2026 0:00	1002	142.7684	11/14/2026 0:00	1048	143.2248
6/30/2026 0:00	911	141.8006	8/15/2026 0:00	957	142.3013	9/30/2026 0:00	1003	142.7786	11/15/2026 0:00	1049	143.2345
7/1/2026 0:00	912	141.8118	8/16/2026 0:00	958	142.3119	10/1/2026 0:00	1004	142.7887	11/16/2026 0:00	1050	143.2442
7/2/2026 0:00	913	141.8229	8/17/2026 0:00	959	142.3225	10/2/2026 0:00	1005	142.7988	11/17/2026 0:00	1051	143.2539
7/3/2026 0:00	914	141.834	8/18/2026 0:00	960	142.3331	10/3/2026 0:00	1006	142.8089	11/18/2026 0:00	1052	143.2635
7/4/2026 0:00	915	141.8451	8/19/2026 0:00	961	142.3437	10/4/2026 0:00	1007	142.819	11/19/2026 0:00	1053	143.2732
7/5/2026 0:00	916	141.8562	8/20/2026 0:00	962	142.3543	10/5/2026 0:00	1008	142.8291	11/20/2026 0:00	1054	143.2828
7/6/2026 0:00	917	141.8673	8/21/2026 0:00	963	142.3648	10/6/2026 0:00	1009	142.8392	11/21/2026 0:00	1055	143.2925
7/7/2026 0:00	918	141.8784	8/22/2026 0:00	964	142.3754	10/7/2026 0:00	1010	142.8493	11/22/2026 0:00	1056	143.3021
7/8/2026 0:00	919	141.8895	8/23/2026 0:00	965	142.3859	10/8/2026 0:00	1011	142.8593	11/23/2026 0:00	1057	143.3117
7/9/2026 0:00	920	141.9005	8/24/2026 0:00	966	142.3964	10/9/2026 0:00	1012	142.8694	11/24/2026 0:00	1058	143.3214
7/10/2026 0:00	921	141.9116	8/25/2026 0:00	967	142.407	10/10/2026 0:00	1013	142.8794	11/25/2026 0:00	1059	143.331
7/11/2026 0:00	922	141.9226	8/26/2026 0:00	968	142.4175	10/11/2026 0:00	1014	142.8894	11/26/2026 0:00	1060	143.3406
7/12/2026 0:00	923	141.9336	8/27/2026 0:00	969	142.428	10/12/2026 0:00	1015	142.8995	11/27/2026 0:00	1061	143.3501
7/13/2026 0:00	924	141.9446	8/28/2026 0:00	970	142.4385	10/13/2026 0:00	1016	142.9095	11/28/2026 0:00	1062	143.3597
7/14/2026 0:00	925	141.9556	8/29/2026 0:00	971	142.4489	10/14/2026 0:00	1017	142.9195	11/29/2026 0:00	1063	143.3693
7/15/2026 0:00	926	141.9666	8/30/2026 0:00	972	142.4594	10/15/2026 0:00	1018	142.9295	11/30/2026 0:00	1064	143.3789
7/16/2026 0:00	927	141.9776	8/31/2026 0:00	973	142.4698	10/16/2026 0:00	1019	142.9395	12/1/2026 0:00	1065	143.3884
7/17/2026 0:00	928	141.9885	9/1/2026 0:00	974	142.4803	10/17/2026 0:00	1020	142.9494	12/2/2026 0:00	1066	143.398
7/18/2026 0:00	929	141.9995	9/2/2026 0:00	975	142.4907	10/18/2026 0:00	1021	142.9594	12/3/2026 0:00	1067	143.4075
7/19/2026 0:00	930	142.0104	9/3/2026 0:00	976	142.5011	10/19/2026 0:00	1022	142.9693	12/4/2026 0:00	1068	143.417
7/20/2026 0:00	931	142.0213	9/4/2026 0:00	977	142.5115	10/20/2026 0:00	1023	142.9793	12/5/2026 0:00	1069	143.4265
7/21/2026 0:00	932	142.0322	9/5/2026 0:00	978	142.5219	10/21/2026 0:00	1024	142.9892	12/6/2026 0:00	1070	143.436
7/22/2026 0:00	933	142.0431	9/6/2026 0:00	979	142.5323	10/22/2026 0:00	1025	142.9992	12/7/2026 0:00	1071	143.4455
7/23/2026 0:00	934	142.054	9/7/2026 0:00	980	142.5427	10/23/2026 0:00	1026	143.0091	12/8/2026 0:00	1072	143.455
7/24/2026 0:00	935	142.0649	9/8/2026 0:00	981	142.5531	10/24/2026 0:00	1027	143.019	12/9/2026 0:00	1073	143.4645
7/25/2026 0:00	936	142.0758	9/9/2026 0:00	982	142.5634	10/25/2026 0:00	1028	143.0289	12/10/2026 0:00	1074	143.474
7/26/2026 0:00	937	142.0866	9/10/2026 0:00	983	142.5738	10/26/2026 0:00	1029	143.0388	12/11/2026 0:00	1075	143.4835
7/27/2026 0:00	938	142.0975	9/11/2026 0:00	984	142.5841	10/27/2026 0:00	1030	143.0486	12/12/2026 0:00	1076	143.4929
7/28/2026 0:00	939	142.1083	9/12/2026 0:00	985	142.5945	10/28/2026 0:00	1031	143.0585	12/13/2026 0:00	1077	143.5024
7/29/2026 0:00	940	142.1191	9/13/2026 0:00	986	142.6048	10/29/2026 0:00	1032	143.0684	12/14/2026 0:00	1078	143.5118
7/30/2026 0:00	941	142.1299	9/14/2026 0:00	987	142.6151	10/30/2026 0:00	1033	143.0782	12/15/2026 0:00	1079	143.5212
7/31/2026 0:00	942	142.1407	9/15/2026 0:00	988	142.6254	10/31/2026 0:00	1034	143.088	12/16/2026 0:00	1080	143.5306
8/1/2026 0:00	943	142.1515	9/16/2026 0:00	989	142.6357	11/1/2026 0:00	1035	143.0979	12/17/2026 0:00	1081	143.5401
8/2/2026 0:00	944	142.1623	9/17/2026 0:00	990	142.6459	11/2/2026 0:00	1036	143.1077	12/18/2026 0:00	1082	143.5495
8/3/2026 0:00	945	142.173	9/18/2026 0:00	991	142.6562	11/3/2026 0:00	1037	143.1175	12/19/2026 0:00	1083	143.5589
8/4/2026 0:00	946	142.1838	9/19/2026 0:00	992	142.6664	11/4/2026 0:00	1038	143.1273	12/20/2026 0:00	1084	143.5682
8/5/2026 0:00	947	142.1945	9/20/2026 0:00	993	142.6767	11/5/2026 0:00	1039	143.1371	12/21/2026 0:00	1085	143.5776
8/6/2026 0:00	948	142.2053	9/21/2026 0:00	994	142.6869	11/6/2026 0:00	1040	143.1469	12/22/2026 0:00	1086	143.587
8/7/2026 0:00	949	142.216	9/22/2026 0:00	995	142.6971	11/7/2026 0:00	1041	143.1566	12/23/2026 0:00	1087	143.5963
8/8/2026 0:00	950	142.2267	9/23/2026 0:00	996	142.7074	11/8/2026 0:00	1042	143.1664	12/24/2026 0:00	1088	143.6057
8/9/2026 0:00	951	142.2374	9/24/2026 0:00	997	142.7176	11/9/2026 0:00	1043	143.1762	12/25/2026 0:00	1089	143.615
8/10/2026 0:00	952	142.2481	9/25/2026 0:00	998	142.7277	11/10/2026 0:00	1044	143.1859	12/26/2026 0:00	1090	143.6244
8/11/2026 0:00	953	142.2587	9/26/2026 0:00	999	142.7379	11/11/2026 0:00	1045	143.1956	12/27/2026 0:00	1091	143.6337

12/28/2026 0:00	1092	143.643	2/12/2027 0:00	1138	144.0627	3/30/2027 0:00	1184	144.4657	5/15/2027 0:00	1230	144.8535
12/29/2026 0:00	1093	143.6523	2/13/2027 0:00	1139	144.0716	3/31/2027 0:00	1185	144.4743	5/16/2027 0:00	1231	144.8618
12/30/2026 0:00	1094	143.6616	2/14/2027 0:00	1140	144.0805	4/1/2027 0:00	1186	144.4829	5/17/2027 0:00	1232	144.87
12/31/2026 0:00	1095	143.6709	2/15/2027 0:00	1141	144.0894	4/2/2027 0:00	1187	144.4915	5/18/2027 0:00	1233	144.8783
1/1/2027 0:00	1096	143.6802	2/16/2027 0:00	1142	144.0984	4/3/2027 0:00	1188	144.5	5/19/2027 0:00	1234	144.8865
1/2/2027 0:00	1097	143.6895	2/17/2027 0:00	1143	144.1073	4/4/2027 0:00	1189	144.5086	5/20/2027 0:00	1235	144.8948
1/3/2027 0:00	1098	143.6987	2/18/2027 0:00	1144	144.1162	4/5/2027 0:00	1190	144.5172	5/21/2027 0:00	1236	144.903
1/4/2027 0:00	1099	143.708	2/19/2027 0:00	1145	144.125	4/6/2027 0:00	1191	144.5257	5/22/2027 0:00	1237	144.9112
1/5/2027 0:00	1100	143.7172	2/20/2027 0:00	1146	144.1339	4/7/2027 0:00	1192	144.5342	5/23/2027 0:00	1238	144.9195
1/6/2027 0:00	1101	143.7265	2/21/2027 0:00	1147	144.1428	4/8/2027 0:00	1193	144.5428	5/24/2027 0:00	1239	144.9277
1/7/2027 0:00	1102	143.7357	2/22/2027 0:00	1148	144.1517	4/9/2027 0:00	1194	144.5513	5/25/2027 0:00	1240	144.9359
1/8/2027 0:00	1103	143.7449	2/23/2027 0:00	1149	144.1605	4/10/2027 0:00	1195	144.5598	5/26/2027 0:00	1241	144.9441
1/9/2027 0:00	1104	143.7542	2/24/2027 0:00	1150	144.1694	4/11/2027 0:00	1196	144.5683	5/27/2027 0:00	1242	144.9523
1/10/2027 0:00	1105	143.7634	2/25/2027 0:00	1151	144.1782	4/12/2027 0:00	1197	144.5768	5/28/2027 0:00	1243	144.9605
1/11/2027 0:00	1106	143.7726	2/26/2027 0:00	1152	144.187	4/13/2027 0:00	1198	144.5853	5/29/2027 0:00	1244	144.9686
1/12/2027 0:00	1107	143.7818	2/27/2027 0:00	1153	144.1959	4/14/2027 0:00	1199	144.5938	5/30/2027 0:00	1245	144.9768
1/13/2027 0:00	1108	143.7909	2/28/2027 0:00	1154	144.2047	4/15/2027 0:00	1200	144.6023	5/31/2027 0:00	1246	144.985
1/14/2027 0:00	1109	143.8001	3/1/2027 0:00	1155	144.2135	4/16/2027 0:00	1201	144.6108	6/1/2027 0:00	1247	144.9931
1/15/2027 0:00	1110	143.8093	3/2/2027 0:00	1156	144.2223	4/17/2027 0:00	1202	144.6192	6/2/2027 0:00	1248	145.0013
1/16/2027 0:00	1111	143.8184	3/3/2027 0:00	1157	144.2311	4/18/2027 0:00	1203	144.6277	6/3/2027 0:00	1249	145.0095
1/17/2027 0:00	1112	143.8276	3/4/2027 0:00	1158	144.2399	4/19/2027 0:00	1204	144.6361	6/4/2027 0:00	1250	145.0176
1/18/2027 0:00	1113	143.8367	3/5/2027 0:00	1159	144.2487	4/20/2027 0:00	1205	144.6446	6/5/2027 0:00	1251	145.0257
1/19/2027 0:00	1114	143.8459	3/6/2027 0:00	1160	144.2574	4/21/2027 0:00	1206	144.653	6/6/2027 0:00	1252	145.0339
1/20/2027 0:00	1115	143.855	3/7/2027 0:00	1161	144.2662	4/22/2027 0:00	1207	144.6615	6/7/2027 0:00	1253	145.042
1/21/2027 0:00	1116	143.8641	3/8/2027 0:00	1162	144.2749	4/23/2027 0:00	1208	144.6699	6/8/2027 0:00	1254	145.0501
1/22/2027 0:00	1117	143.8732	3/9/2027 0:00	1163	144.2837	4/24/2027 0:00	1209	144.6783	6/9/2027 0:00	1255	145.0582
1/23/2027 0:00	1118	143.8823	3/10/2027 0:00	1164	144.2924	4/25/2027 0:00	1210	144.6867	6/10/2027 0:00	1256	145.0663
1/24/2027 0:00	1119	143.8914	3/11/2027 0:00	1165	144.3012	4/26/2027 0:00	1211	144.6951	6/11/2027 0:00	1257	145.0744
1/25/2027 0:00	1120	143.9005	3/12/2027 0:00	1166	144.3099	4/27/2027 0:00	1212	144.7035	6/12/2027 0:00	1258	145.0825
1/26/2027 0:00	1121	143.9096	3/13/2027 0:00	1167	144.3186	4/28/2027 0:00	1213	144.7119	6/13/2027 0:00	1259	145.0906
1/27/2027 0:00	1122	143.9186	3/14/2027 0:00	1168	144.3273	4/29/2027 0:00	1214	144.7203	6/14/2027 0:00	1260	145.0987
1/28/2027 0:00	1123	143.9277	3/15/2027 0:00	1169	144.336	4/30/2027 0:00	1215	144.7287	6/15/2027 0:00	1261	145.1067
1/29/2027 0:00	1124	143.9368	3/16/2027 0:00	1170	144.3447	5/1/2027 0:00	1216	144.737	6/16/2027 0:00	1262	145.1148
1/30/2027 0:00	1125	143.9458	3/17/2027 0:00	1171	144.3534	5/2/2027 0:00	1217	144.7454	6/17/2027 0:00	1263	145.1229
1/31/2027 0:00	1126	143.9548	3/18/2027 0:00	1172	144.3621	5/3/2027 0:00	1218	144.7538	6/18/2027 0:00	1264	145.1309
2/1/2027 0:00	1127	143.9639	3/19/2027 0:00	1173	144.3708	5/4/2027 0:00	1219	144.7621	6/19/2027 0:00	1265	145.139
2/2/2027 0:00	1128	143.9729	3/20/2027 0:00	1174	144.3795	5/5/2027 0:00	1220	144.7704	6/20/2027 0:00	1266	145.147
2/3/2027 0:00	1129	143.9819	3/21/2027 0:00	1175	144.3881	5/6/2027 0:00	1221	144.7788	6/21/2027 0:00	1267	145.155
2/4/2027 0:00	1130	143.9909	3/22/2027 0:00	1176	144.3968	5/7/2027 0:00	1222	144.7871	6/22/2027 0:00	1268	145.1631
2/5/2027 0:00	1131	143.9999	3/23/2027 0:00	1177	144.4054	5/8/2027 0:00	1223	144.7954	6/23/2027 0:00	1269	145.1711
2/6/2027 0:00	1132	144.0089	3/24/2027 0:00	1178	144.4141	5/9/2027 0:00	1224	144.8037	6/24/2027 0:00	1270	145.1791
2/7/2027 0:00	1133	144.0179	3/25/2027 0:00	1179	144.4227	5/10/2027 0:00	1225	144.8121	6/25/2027 0:00	1271	145.1871
2/8/2027 0:00	1134	144.0269	3/26/2027 0:00	1180	144.4313	5/11/2027 0:00	1226	144.8204	6/26/2027 0:00	1272	145.1951
2/9/2027 0:00	1135	144.0358	3/27/2027 0:00	1181	144.4399	5/12/2027 0:00	1227	144.8287	6/27/2027 0:00	1273	145.2031
2/10/2027 0:00	1136	144.0448	3/28/2027 0:00	1182	144.4485	5/13/2027 0:00	1228	144.8369	6/28/2027 0:00	1274	145.2111
2/11/2027 0:00	1137	144.0537	3/29/2027 0:00	1183	144.4571	5/14/2027 0:00	1229	144.8452	6/29/2027 0:00	1275	145.2191

6/30/2027 0:00	1276	145.2271	8/15/2027 0:00	1322	145.5874	9/30/2027 0:00	1368	145.9355	11/15/2027 0:00	1414	146.2721
7/1/2027 0:00	1277	145.235	8/16/2027 0:00	1323	145.5951	10/1/2027 0:00	1369	145.9429	11/16/2027 0:00	1415	146.2793
7/2/2027 0:00	1278	145.243	8/17/2027 0:00	1324	145.6028	10/2/2027 0:00	1370	145.9504	11/17/2027 0:00	1416	146.2865
7/3/2027 0:00	1279	145.2509	8/18/2027 0:00	1325	145.6105	10/3/2027 0:00	1371	145.9578	11/18/2027 0:00	1417	146.2937
7/4/2027 0:00	1280	145.2589	8/19/2027 0:00	1326	145.6182	10/4/2027 0:00	1372	145.9652	11/19/2027 0:00	1418	146.3008
7/5/2027 0:00	1281	145.2668	8/20/2027 0:00	1327	145.6258	10/5/2027 0:00	1373	145.9726	11/20/2027 0:00	1419	146.308
7/6/2027 0:00	1282	145.2748	8/21/2027 0:00	1328	145.6335	10/6/2027 0:00	1374	145.98	11/21/2027 0:00	1420	146.3152
7/7/2027 0:00	1283	145.2827	8/22/2027 0:00	1329	145.6412	10/7/2027 0:00	1375	145.9874	11/22/2027 0:00	1421	146.3224
7/8/2027 0:00	1284	145.2906	8/23/2027 0:00	1330	145.6488	10/8/2027 0:00	1376	145.9948	11/23/2027 0:00	1422	146.3295
7/9/2027 0:00	1285	145.2986	8/24/2027 0:00	1331	145.6565	10/9/2027 0:00	1377	146.0022	11/24/2027 0:00	1423	146.3367
7/10/2027 0:00	1286	145.3065	8/25/2027 0:00	1332	145.6641	10/10/2027 0:00	1378	146.0096	11/25/2027 0:00	1424	146.3438
7/11/2027 0:00	1287	145.3144	8/26/2027 0:00	1333	145.6717	10/11/2027 0:00	1379	146.017	11/26/2027 0:00	1425	146.351
7/12/2027 0:00	1288	145.3223	8/27/2027 0:00	1334	145.6794	10/12/2027 0:00	1380	146.0244	11/27/2027 0:00	1426	146.3581
7/13/2027 0:00	1289	145.3302	8/28/2027 0:00	1335	145.687	10/13/2027 0:00	1381	146.0318	11/28/2027 0:00	1427	146.3652
7/14/2027 0:00	1290	145.3381	8/29/2027 0:00	1336	145.6946	10/14/2027 0:00	1382	146.0391	11/29/2027 0:00	1428	146.3724
7/15/2027 0:00	1291	145.346	8/30/2027 0:00	1337	145.7022	10/15/2027 0:00	1383	146.0465	11/30/2027 0:00	1429	146.3795
7/16/2027 0:00	1292	145.3538	8/31/2027 0:00	1338	145.7098	10/16/2027 0:00	1384	146.0538	12/1/2027 0:00	1430	146.3866
7/17/2027 0:00	1293	145.3617	9/1/2027 0:00	1339	145.7174	10/17/2027 0:00	1385	146.0612	12/2/2027 0:00	1431	146.3937
7/18/2027 0:00	1294	145.3696	9/2/2027 0:00	1340	145.725	10/18/2027 0:00	1386	146.0685	12/3/2027 0:00	1432	146.4008
7/19/2027 0:00	1295	145.3774	9/3/2027 0:00	1341	145.7326	10/19/2027 0:00	1387	146.0759	12/4/2027 0:00	1433	146.4079
7/20/2027 0:00	1296	145.3853	9/4/2027 0:00	1342	145.7402	10/20/2027 0:00	1388	146.0832	12/5/2027 0:00	1434	146.415
7/21/2027 0:00	1297	145.3932	9/5/2027 0:00	1343	145.7478	10/21/2027 0:00	1389	146.0905	12/6/2027 0:00	1435	146.4221
7/22/2027 0:00	1298	145.401	9/6/2027 0:00	1344	145.7554	10/22/2027 0:00	1390	146.0979	12/7/2027 0:00	1436	146.4292
7/23/2027 0:00	1299	145.4088	9/7/2027 0:00	1345	145.7629	10/23/2027 0:00	1391	146.1052	12/8/2027 0:00	1437	146.4363
7/24/2027 0:00	1300	145.4167	9/8/2027 0:00	1346	145.7705	10/24/2027 0:00	1392	146.1125	12/9/2027 0:00	1438	146.4434
7/25/2027 0:00	1301	145.4245	9/9/2027 0:00	1347	145.7781	10/25/2027 0:00	1393	146.1198	12/10/2027 0:00	1439	146.4505
7/26/2027 0:00	1302	145.4323	9/10/2027 0:00	1348	145.7856	10/26/2027 0:00	1394	146.1271	12/11/2027 0:00	1440	146.4575
7/27/2027 0:00	1303	145.4401	9/11/2027 0:00	1349	145.7932	10/27/2027 0:00	1395	146.1344	12/12/2027 0:00	1441	146.4646
7/28/2027 0:00	1304	145.4479	9/12/2027 0:00	1350	145.8007	10/28/2027 0:00	1396	146.1417	12/13/2027 0:00	1442	146.4717
7/29/2027 0:00	1305	145.4557	9/13/2027 0:00	1351	145.8082	10/29/2027 0:00	1397	146.149	12/14/2027 0:00	1443	146.4787
7/30/2027 0:00	1306	145.4635	9/14/2027 0:00	1352	145.8158	10/30/2027 0:00	1398	146.1563	12/15/2027 0:00	1444	146.4858
7/31/2027 0:00	1307	145.4713	9/15/2027 0:00	1353	145.8233	10/31/2027 0:00	1399	146.1635	12/16/2027 0:00	1445	146.4928
8/1/2027 0:00	1308	145.4791	9/16/2027 0:00	1354	145.8308	11/1/2027 0:00	1400	146.1708	12/17/2027 0:00	1446	146.4999
8/2/2027 0:00	1309	145.4869	9/17/2027 0:00	1355	145.8383	11/2/2027 0:00	1401	146.1781	12/18/2027 0:00	1447	146.5069
8/3/2027 0:00	1310	145.4946	9/18/2027 0:00	1356	145.8458	11/3/2027 0:00	1402	146.1854	12/19/2027 0:00	1448	146.5139
8/4/2027 0:00	1311	145.5024	9/19/2027 0:00	1357	145.8533	11/4/2027 0:00	1403	146.1926	12/20/2027 0:00	1449	146.521
8/5/2027 0:00	1312	145.5102	9/20/2027 0:00	1358	145.8608	11/5/2027 0:00	1404	146.1999	12/21/2027 0:00	1450	146.528
8/6/2027 0:00	1313	145.5179	9/21/2027 0:00	1359	145.8683	11/6/2027 0:00	1405	146.2071	12/22/2027 0:00	1451	146.535
8/7/2027 0:00	1314	145.5257	9/22/2027 0:00	1360	145.8758	11/7/2027 0:00	1406	146.2143	12/23/2027 0:00	1452	146.542
8/8/2027 0:00	1315	145.5334	9/23/2027 0:00	1361	145.8833	11/8/2027 0:00	1407	146.2216	12/24/2027 0:00	1453	146.549
8/9/2027 0:00	1316	145.5411	9/24/2027 0:00	1362	145.8908	11/9/2027 0:00	1408	146.2288	12/25/2027 0:00	1454	146.556
8/10/2027 0:00	1317	145.5489	9/25/2027 0:00	1363	145.8982	11/10/2027 0:00	1409	146.236	12/26/2027 0:00	1455	146.563
8/11/2027 0:00	1318	145.5566	9/26/2027 0:00	1364	145.9057	11/11/2027 0:00	1410	146.2433	12/27/2027 0:00	1456	146.57
8/12/2027 0:00	1319	145.5643	9/27/2027 0:00	1365	145.9132	11/12/2027 0:00	1411	146.2505	12/28/2027 0:00	1457	146.577
8/13/2027 0:00	1320	145.572	9/28/2027 0:00	1366	145.9206	11/13/2027 0:00	1412	146.2577	12/29/2027 0:00	1458	146.584
8/14/2027 0:00	1321	145.5797	9/29/2027 0:00	1367	145.9281	11/14/2027 0:00	1413	146.2649	12/30/2027 0:00	1459	146.591

12/31/2027 0:00	1460	146.5979	2/15/2028 0:00	1506	146.9137	4/1/2028 0:00	1552	147.22	5/17/2028 0:00	1598	147.5173
1/1/2028 0:00	1461	146.6049	2/16/2028 0:00	1507	146.9205	4/2/2028 0:00	1553	147.2265	5/18/2028 0:00	1599	147.5237
1/2/2028 0:00	1462	146.6119	2/17/2028 0:00	1508	146.9272	4/3/2028 0:00	1554	147.2331	5/19/2028 0:00	1600	147.5301
1/3/2028 0:00	1463	146.6188	2/18/2028 0:00	1509	146.934	4/4/2028 0:00	1555	147.2396	5/20/2028 0:00	1601	147.5364
1/4/2028 0:00	1464	146.6258	2/19/2028 0:00	1510	146.9407	4/5/2028 0:00	1556	147.2462	5/21/2028 0:00	1602	147.5428
1/5/2028 0:00	1465	146.6327	2/20/2028 0:00	1511	146.9474	4/6/2028 0:00	1557	147.2527	5/22/2028 0:00	1603	147.5492
1/6/2028 0:00	1466	146.6397	2/21/2028 0:00	1512	146.9542	4/7/2028 0:00	1558	147.2593	5/23/2028 0:00	1604	147.5555
1/7/2028 0:00	1467	146.6466	2/22/2028 0:00	1513	146.9609	4/8/2028 0:00	1559	147.2658	5/24/2028 0:00	1605	147.5618
1/8/2028 0:00	1468	146.6536	2/23/2028 0:00	1514	146.9676	4/9/2028 0:00	1560	147.2723	5/25/2028 0:00	1606	147.5682
1/9/2028 0:00	1469	146.6605	2/24/2028 0:00	1515	146.9744	4/10/2028 0:00	1561	147.2789	5/26/2028 0:00	1607	147.5745
1/10/2028 0:00	1470	146.6674	2/25/2028 0:00	1516	146.9811	4/11/2028 0:00	1562	147.2854	5/27/2028 0:00	1608	147.5809
1/11/2028 0:00	1471	146.6743	2/26/2028 0:00	1517	146.9878	4/12/2028 0:00	1563	147.2919	5/28/2028 0:00	1609	147.5872
1/12/2028 0:00	1472	146.6813	2/27/2028 0:00	1518	146.9945	4/13/2028 0:00	1564	147.2984	5/29/2028 0:00	1610	147.5935
1/13/2028 0:00	1473	146.6882	2/28/2028 0:00	1519	147.0012	4/14/2028 0:00	1565	147.3049	5/30/2028 0:00	1611	147.5998
1/14/2028 0:00	1474	146.6951	2/29/2028 0:00	1520	147.0079	4/15/2028 0:00	1566	147.3114	5/31/2028 0:00	1612	147.6062
1/15/2028 0:00	1475	146.702	3/1/2028 0:00	1521	147.0146	4/16/2028 0:00	1567	147.3179	6/1/2028 0:00	1613	147.6125
1/16/2028 0:00	1476	146.7089	3/2/2028 0:00	1522	147.0213	4/17/2028 0:00	1568	147.3244	6/2/2028 0:00	1614	147.6188
1/17/2028 0:00	1477	146.7158	3/3/2028 0:00	1523	147.028	4/18/2028 0:00	1569	147.3309	6/3/2028 0:00	1615	147.6251
1/18/2028 0:00	1478	146.7227	3/4/2028 0:00	1524	147.0346	4/19/2028 0:00	1570	147.3374	6/4/2028 0:00	1616	147.6314
1/19/2028 0:00	1479	146.7295	3/5/2028 0:00	1525	147.0413	4/20/2028 0:00	1571	147.3439	6/5/2028 0:00	1617	147.6377
1/20/2028 0:00	1480	146.7364	3/6/2028 0:00	1526	147.048	4/21/2028 0:00	1572	147.3503	6/6/2028 0:00	1618	147.644
1/21/2028 0:00	1481	146.7433	3/7/2028 0:00	1527	147.0547	4/22/2028 0:00	1573	147.3568	6/7/2028 0:00	1619	147.6503
1/22/2028 0:00	1482	146.7502	3/8/2028 0:00	1528	147.0613	4/23/2028 0:00	1574	147.3633	6/8/2028 0:00	1620	147.6566
1/23/2028 0:00	1483	146.757	3/9/2028 0:00	1529	147.068	4/24/2028 0:00	1575	147.3697	6/9/2028 0:00	1621	147.6628
1/24/2028 0:00	1484	146.7639	3/10/2028 0:00	1530	147.0746	4/25/2028 0:00	1576	147.3762	6/10/2028 0:00	1622	147.6691
1/25/2028 0:00	1485	146.7708	3/11/2028 0:00	1531	147.0813	4/26/2028 0:00	1577	147.3827	6/11/2028 0:00	1623	147.6754
1/26/2028 0:00	1486	146.7776	3/12/2028 0:00	1532	147.0879	4/27/2028 0:00	1578	147.3891	6/12/2028 0:00	1624	147.6817
1/27/2028 0:00	1487	146.7845	3/13/2028 0:00	1533	147.0946	4/28/2028 0:00	1579	147.3956	6/13/2028 0:00	1625	147.6879
1/28/2028 0:00	1488	146.7913	3/14/2028 0:00	1534	147.1012	4/29/2028 0:00	1580	147.402	6/14/2028 0:00	1626	147.6942
1/29/2028 0:00	1489	146.7981	3/15/2028 0:00	1535	147.1079	4/30/2028 0:00	1581	147.4085	6/15/2028 0:00	1627	147.7005
1/30/2028 0:00	1490	146.805	3/16/2028 0:00	1536	147.1145	5/1/2028 0:00	1582	147.4149	6/16/2028 0:00	1628	147.7067
1/31/2028 0:00	1491	146.8118	3/17/2028 0:00	1537	147.1211	5/2/2028 0:00	1583	147.4213	6/17/2028 0:00	1629	147.713
2/1/2028 0:00	1492	146.8186	3/18/2028 0:00	1538	147.1277	5/3/2028 0:00	1584	147.4278	6/18/2028 0:00	1630	147.7192
2/2/2028 0:00	1493	146.8254	3/19/2028 0:00	1539	147.1344	5/4/2028 0:00	1585	147.4342	6/19/2028 0:00	1631	147.7255
2/3/2028 0:00	1494	146.8323	3/20/2028 0:00	1540	147.141	5/5/2028 0:00	1586	147.4406	6/20/2028 0:00	1632	147.7317
2/4/2028 0:00	1495	146.8391	3/21/2028 0:00	1541	147.1476	5/6/2028 0:00	1587	147.447	6/21/2028 0:00	1633	147.7379
2/5/2028 0:00	1496	146.8459	3/22/2028 0:00	1542	147.1542	5/7/2028 0:00	1588	147.4534	6/22/2028 0:00	1634	147.7442
2/6/2028 0:00	1497	146.8527	3/23/2028 0:00	1543	147.1608	5/8/2028 0:00	1589	147.4598	6/23/2028 0:00	1635	147.7504
2/7/2028 0:00	1498	146.8595	3/24/2028 0:00	1544	147.1674	5/9/2028 0:00	1590	147.4662	6/24/2028 0:00	1636	147.7566
2/8/2028 0:00	1499	146.8663	3/25/2028 0:00	1545	147.174	5/10/2028 0:00	1591	147.4726	6/25/2028 0:00	1637	147.7628
2/9/2028 0:00	1500	146.8731	3/26/2028 0:00	1546	147.1806	5/11/2028 0:00	1592	147.479	6/26/2028 0:00	1638	147.7691
2/10/2028 0:00	1501	146.8798	3/27/2028 0:00	1547	147.1871	5/12/2028 0:00	1593	147.4854	6/27/2028 0:00	1639	147.7753
2/11/2028 0:00	1502	146.8866	3/28/2028 0:00	1548	147.1937	5/13/2028 0:00	1594	147.4918	6/28/2028 0:00	1640	147.7815
2/12/2028 0:00	1503	146.8934	3/29/2028 0:00	1549	147.2003	5/14/2028 0:00	1595	147.4982	6/29/2028 0:00	1641	147.7877
2/13/2028 0:00	1504	146.9002	3/30/2028 0:00	1550	147.2069	5/15/2028 0:00	1596	147.5046	6/30/2028 0:00	1642	147.7939
2/14/2028 0:00	1505	146.9069	3/31/2028 0:00	1551	147.2134	5/16/2028 0:00	1597	147.511	7/1/2028 0:00	1643	147.8001

7/2/2028 0:00	1644	147.8063	8/17/2028 0:00	1690	148.0873	10/2/2028 0:00	1736	148.3607	11/17/2028 0:00	1782	148.627
7/3/2028 0:00	1645	147.8125	8/18/2028 0:00	1691	148.0933	10/3/2028 0:00	1737	148.3666	11/18/2028 0:00	1783	148.6328
7/4/2028 0:00	1646	147.8187	8/19/2028 0:00	1692	148.0993	10/4/2028 0:00	1738	148.3724	11/19/2028 0:00	1784	148.6385
7/5/2028 0:00	1647	147.8248	8/20/2028 0:00	1693	148.1053	10/5/2028 0:00	1739	148.3783	11/20/2028 0:00	1785	148.6442
7/6/2028 0:00	1648	147.831	8/21/2028 0:00	1694	148.1113	10/6/2028 0:00	1740	148.3842	11/21/2028 0:00	1786	148.6499
7/7/2028 0:00	1649	147.8372	8/22/2028 0:00	1695	148.1173	10/7/2028 0:00	1741	148.39	11/22/2028 0:00	1787	148.6556
7/8/2028 0:00	1650	147.8434	8/23/2028 0:00	1696	148.1234	10/8/2028 0:00	1742	148.3959	11/23/2028 0:00	1788	148.6613
7/9/2028 0:00	1651	147.8495	8/24/2028 0:00	1697	148.1294	10/9/2028 0:00	1743	148.4017	11/24/2028 0:00	1789	148.667
7/10/2028 0:00	1652	147.8557	8/25/2028 0:00	1698	148.1354	10/10/2028 0:00	1744	148.4075	11/25/2028 0:00	1790	148.6727
7/11/2028 0:00	1653	147.8619	8/26/2028 0:00	1699	148.1414	10/11/2028 0:00	1745	148.4134	11/26/2028 0:00	1791	148.6783
7/12/2028 0:00	1654	147.868	8/27/2028 0:00	1700	148.1473	10/12/2028 0:00	1746	148.4192	11/27/2028 0:00	1792	148.684
7/13/2028 0:00	1655	147.8742	8/28/2028 0:00	1701	148.1533	10/13/2028 0:00	1747	148.425	11/28/2028 0:00	1793	148.6897
7/14/2028 0:00	1656	147.8803	8/29/2028 0:00	1702	148.1593	10/14/2028 0:00	1748	148.4309	11/29/2028 0:00	1794	148.6954
7/15/2028 0:00	1657	147.8865	8/30/2028 0:00	1703	148.1653	10/15/2028 0:00	1749	148.4367	11/30/2028 0:00	1795	148.7011
7/16/2028 0:00	1658	147.8926	8/31/2028 0:00	1704	148.1713	10/16/2028 0:00	1750	148.4425	12/1/2028 0:00	1796	148.7067
7/17/2028 0:00	1659	147.8988	9/1/2028 0:00	1705	148.1772	10/17/2028 0:00	1751	148.4483	12/2/2028 0:00	1797	148.7124
7/18/2028 0:00	1660	147.9049	9/2/2028 0:00	1706	148.1832	10/18/2028 0:00	1752	148.4541	12/3/2028 0:00	1798	148.7181
7/19/2028 0:00	1661	147.911	9/3/2028 0:00	1707	148.1892	10/19/2028 0:00	1753	148.46	12/4/2028 0:00	1799	148.7237
7/20/2028 0:00	1662	147.9172	9/4/2028 0:00	1708	148.1951	10/20/2028 0:00	1754	148.4658	12/5/2028 0:00	1800	148.7294
7/21/2028 0:00	1663	147.9233	9/5/2028 0:00	1709	148.2011	10/21/2028 0:00	1755	148.4716	12/6/2028 0:00	1801	148.735
7/22/2028 0:00	1664	147.9294	9/6/2028 0:00	1710	148.2071	10/22/2028 0:00	1756	148.4774	12/7/2028 0:00	1802	148.7407
7/23/2028 0:00	1665	147.9355	9/7/2028 0:00	1711	148.213	10/23/2028 0:00	1757	148.4832	12/8/2028 0:00	1803	148.7463
7/24/2028 0:00	1666	147.9416	9/8/2028 0:00	1712	148.219	10/24/2028 0:00	1758	148.489	12/9/2028 0:00	1804	148.752
7/25/2028 0:00	1667	147.9477	9/9/2028 0:00	1713	148.2249	10/25/2028 0:00	1759	148.4948	12/10/2028 0:00	1805	148.7576
7/26/2028 0:00	1668	147.9539	9/10/2028 0:00	1714	148.2309	10/26/2028 0:00	1760	148.5005	12/11/2028 0:00	1806	148.7633
7/27/2028 0:00	1669	147.96	9/11/2028 0:00	1715	148.2368	10/27/2028 0:00	1761	148.5063	12/12/2028 0:00	1807	148.7689
7/28/2028 0:00	1670	147.9661	9/12/2028 0:00	1716	148.2427	10/28/2028 0:00	1762	148.5121	12/13/2028 0:00	1808	148.7745
7/29/2028 0:00	1671	147.9721	9/13/2028 0:00	1717	148.2487	10/29/2028 0:00	1763	148.5179	12/14/2028 0:00	1809	148.7802
7/30/2028 0:00	1672	147.9782	9/14/2028 0:00	1718	148.2546	10/30/2028 0:00	1764	148.5237	12/15/2028 0:00	1810	148.7858
7/31/2028 0:00	1673	147.9843	9/15/2028 0:00	1719	148.2605	10/31/2028 0:00	1765	148.5294	12/16/2028 0:00	1811	148.7914
8/1/2028 0:00	1674	147.9904	9/16/2028 0:00	1720	148.2664	11/1/2028 0:00	1766	148.5352	12/17/2028 0:00	1812	148.7971
8/2/2028 0:00	1675	147.9965	9/17/2028 0:00	1721	148.2724	11/2/2028 0:00	1767	148.541	12/18/2028 0:00	1813	148.8027
8/3/2028 0:00	1676	148.0026	9/18/2028 0:00	1722	148.2783	11/3/2028 0:00	1768	148.5467	12/19/2028 0:00	1814	148.8083
8/4/2028 0:00	1677	148.0086	9/19/2028 0:00	1723	148.2842	11/4/2028 0:00	1769	148.5525	12/20/2028 0:00	1815	148.8139
8/5/2028 0:00	1678	148.0147	9/20/2028 0:00	1724	148.2901	11/5/2028 0:00	1770	148.5582	12/21/2028 0:00	1816	148.8195
8/6/2028 0:00	1679	148.0208	9/21/2028 0:00	1725	148.296	11/6/2028 0:00	1771	148.564	12/22/2028 0:00	1817	148.8251
8/7/2028 0:00	1680	148.0268	9/22/2028 0:00	1726	148.3019	11/7/2028 0:00	1772	148.5697	12/23/2028 0:00	1818	148.8307
8/8/2028 0:00	1681	148.0329	9/23/2028 0:00	1727	148.3078	11/8/2028 0:00	1773	148.5755	12/24/2028 0:00	1819	148.8363
8/9/2028 0:00	1682	148.039	9/24/2028 0:00	1728	148.3137	11/9/2028 0:00	1774	148.5812	12/25/2028 0:00	1820	148.8419
8/10/2028 0:00	1683	148.045	9/25/2028 0:00	1729	148.3196	11/10/2028 0:00	1775	148.587	12/26/2028 0:00	1821	148.8475
8/11/2028 0:00	1684	148.0511	9/26/2028 0:00	1730	148.3255	11/11/2028 0:00	1776	148.5927	12/27/2028 0:00	1822	148.8531
8/12/2028 0:00	1685	148.0571	9/27/2028 0:00	1731	148.3314	11/12/2028 0:00	1777	148.5984	12/28/2028 0:00	1823	148.8587
8/13/2028 0:00	1686	148.0631	9/28/2028 0:00	1732	148.3372	11/13/2028 0:00	1778	148.6042	12/29/2028 0:00	1824	148.8643
8/14/2028 0:00	1687	148.0692	9/29/2028 0:00	1733	148.3431	11/14/2028 0:00	1779	148.6099	12/30/2028 0:00	1825	148.8699
8/15/2028 0:00	1688	148.0752	9/30/2028 0:00	1734	148.349	11/15/2028 0:00	1780	148.6156	12/31/2028 0:00	1826	148.8754
8/16/2028 0:00	1689	148.0812	10/1/2028 0:00	1735	148.3549	11/16/2028 0:00	1781	148.6213	1/1/2029 0:00	1827	148.881

1/2/2029 0:00	1828	148.8866	2/17/2029 0:00	1874	149.1397	4/4/2029 0:00	1920	149.3867	5/20/2029 0:00	1966	149.6278
1/3/2029 0:00	1829	148.8922	2/18/2029 0:00	1875	149.1451	4/5/2029 0:00	1921	149.392	5/21/2029 0:00	1967	149.633
1/4/2029 0:00	1830	148.8977	2/19/2029 0:00	1876	149.1506	4/6/2029 0:00	1922	149.3973	5/22/2029 0:00	1968	149.6382
1/5/2029 0:00	1831	148.9033	2/20/2029 0:00	1877	149.156	4/7/2029 0:00	1923	149.4026	5/23/2029 0:00	1969	149.6433
1/6/2029 0:00	1832	148.9088	2/21/2029 0:00	1878	149.1614	4/8/2029 0:00	1924	149.4079	5/24/2029 0:00	1970	149.6485
1/7/2029 0:00	1833	148.9144	2/22/2029 0:00	1879	149.1668	4/9/2029 0:00	1925	149.4132	5/25/2029 0:00	1971	149.6537
1/8/2029 0:00	1834	148.92	2/23/2029 0:00	1880	149.1722	4/10/2029 0:00	1926	149.4185	5/26/2029 0:00	1972	149.6589
1/9/2029 0:00	1835	148.9255	2/24/2029 0:00	1881	149.1777	4/11/2029 0:00	1927	149.4237	5/27/2029 0:00	1973	149.664
1/10/2029 0:00	1836	148.9311	2/25/2029 0:00	1882	149.1831	4/12/2029 0:00	1928	149.429	5/28/2029 0:00	1974	149.6692
1/11/2029 0:00	1837	148.9366	2/26/2029 0:00	1883	149.1885	4/13/2029 0:00	1929	149.4343	5/29/2029 0:00	1975	149.6743
1/12/2029 0:00	1838	148.9421	2/27/2029 0:00	1884	149.1939	4/14/2029 0:00	1930	149.4396	5/30/2029 0:00	1976	149.6795
1/13/2029 0:00	1839	148.9477	2/28/2029 0:00	1885	149.1993	4/15/2029 0:00	1931	149.4449	5/31/2029 0:00	1977	149.6846
1/14/2029 0:00	1840	148.9532	3/1/2029 0:00	1886	149.2047	4/16/2029 0:00	1932	149.4501	6/1/2029 0:00	1978	149.6898
1/15/2029 0:00	1841	148.9588	3/2/2029 0:00	1887	149.2101	4/17/2029 0:00	1933	149.4554	6/2/2029 0:00	1979	149.6949
1/16/2029 0:00	1842	148.9643	3/3/2029 0:00	1888	149.2155	4/18/2029 0:00	1934	149.4607	6/3/2029 0:00	1980	149.7001
1/17/2029 0:00	1843	148.9698	3/4/2029 0:00	1889	149.2209	4/19/2029 0:00	1935	149.4659	6/4/2029 0:00	1981	149.7052
1/18/2029 0:00	1844	148.9753	3/5/2029 0:00	1890	149.2263	4/20/2029 0:00	1936	149.4712	6/5/2029 0:00	1982	149.7104
1/19/2029 0:00	1845	148.9809	3/6/2029 0:00	1891	149.2317	4/21/2029 0:00	1937	149.4765	6/6/2029 0:00	1983	149.7155
1/20/2029 0:00	1846	148.9864	3/7/2029 0:00	1892	149.237	4/22/2029 0:00	1938	149.4817	6/7/2029 0:00	1984	149.7206
1/21/2029 0:00	1847	148.9919	3/8/2029 0:00	1893	149.2424	4/23/2029 0:00	1939	149.487	6/8/2029 0:00	1985	149.7258
1/22/2029 0:00	1848	148.9974	3/9/2029 0:00	1894	149.2478	4/24/2029 0:00	1940	149.4922	6/9/2029 0:00	1986	149.7309
1/23/2029 0:00	1849	149.0029	3/10/2029 0:00	1895	149.2532	4/25/2029 0:00	1941	149.4975	6/10/2029 0:00	1987	149.736
1/24/2029 0:00	1850	149.0084	3/11/2029 0:00	1896	149.2586	4/26/2029 0:00	1942	149.5027	6/11/2029 0:00	1988	149.7412
1/25/2029 0:00	1851	149.0139	3/12/2029 0:00	1897	149.2639	4/27/2029 0:00	1943	149.508	6/12/2029 0:00	1989	149.7463
1/26/2029 0:00	1852	149.0194	3/13/2029 0:00	1898	149.2693	4/28/2029 0:00	1944	149.5132	6/13/2029 0:00	1990	149.7514
1/27/2029 0:00	1853	149.0249	3/14/2029 0:00	1899	149.2747	4/29/2029 0:00	1945	149.5184	6/14/2029 0:00	1991	149.7565
1/28/2029 0:00	1854	149.0304	3/15/2029 0:00	1900	149.28	4/30/2029 0:00	1946	149.5237	6/15/2029 0:00	1992	149.7616
1/29/2029 0:00	1855	149.0359	3/16/2029 0:00	1901	149.2854	5/1/2029 0:00	1947	149.5289	6/16/2029 0:00	1993	149.7667
1/30/2029 0:00	1856	149.0414	3/17/2029 0:00	1902	149.2907	5/2/2029 0:00	1948	149.5341	6/17/2029 0:00	1994	149.7719
1/31/2029 0:00	1857	149.0469	3/18/2029 0:00	1903	149.2961	5/3/2029 0:00	1949	149.5394	6/18/2029 0:00	1995	149.777
2/1/2029 0:00	1858	149.0524	3/19/2029 0:00	1904	149.3014	5/4/2029 0:00	1950	149.5446	6/19/2029 0:00	1996	149.7821
2/2/2029 0:00	1859	149.0578	3/20/2029 0:00	1905	149.3068	5/5/2029 0:00	1951	149.5498	6/20/2029 0:00	1997	149.7872
2/3/2029 0:00	1860	149.0633	3/21/2029 0:00	1906	149.3121	5/6/2029 0:00	1952	149.555	6/21/2029 0:00	1998	149.7923
2/4/2029 0:00	1861	149.0688	3/22/2029 0:00	1907	149.3175	5/7/2029 0:00	1953	149.5602	6/22/2029 0:00	1999	149.7974
2/5/2029 0:00	1862	149.0743	3/23/2029 0:00	1908	149.3228	5/8/2029 0:00	1954	149.5655	6/23/2029 0:00	2000	149.8025
2/6/2029 0:00	1863	149.0797	3/24/2029 0:00	1909	149.3282	5/9/2029 0:00	1955	149.5707	6/24/2029 0:00	2001	149.8076
2/7/2029 0:00	1864	149.0852	3/25/2029 0:00	1910	149.3335	5/10/2029 0:00	1956	149.5759	6/25/2029 0:00	2002	149.8126
2/8/2029 0:00	1865	149.0907	3/26/2029 0:00	1911	149.3388	5/11/2029 0:00	1957	149.5811	6/26/2029 0:00	2003	149.8177
2/9/2029 0:00	1866	149.0961	3/27/2029 0:00	1912	149.3441	5/12/2029 0:00	1958	149.5863	6/27/2029 0:00	2004	149.8228
2/10/2029 0:00	1867	149.1016	3/28/2029 0:00	1913	149.3495	5/13/2029 0:00	1959	149.5915	6/28/2029 0:00	2005	149.8279
2/11/2029 0:00	1868	149.107	3/29/2029 0:00	1914	149.3548	5/14/2029 0:00	1960	149.5967	6/29/2029 0:00	2006	149.833
2/12/2029 0:00	1869	149.1125	3/30/2029 0:00	1915	149.3601	5/15/2029 0:00	1961	149.6019	6/30/2029 0:00	2007	149.838
2/13/2029 0:00	1870	149.1179	3/31/2029 0:00	1916	149.3654	5/16/2029 0:00	1962	149.6071	7/1/2029 0:00	2008	149.8431
2/14/2029 0:00	1871	149.1234	4/1/2029 0:00	1917	149.3707	5/17/2029 0:00	1963	149.6123	7/2/2029 0:00	2009	149.8482
2/15/2029 0:00	1872	149.1288	4/2/2029 0:00	1918	149.3761	5/18/2029 0:00	1964	149.6174	7/3/2029 0:00	2010	149.8533
2/16/2029 0:00	1873	149.1343	4/3/2029 0:00	1919	149.3814	5/19/2029 0:00	1965	149.6226	7/4/2029 0:00	2011	149.8583

7/5/2029 0:00	2012	149.8634	8/20/2029 0:00	2058	150.0937	10/5/2029 0:00	2104	150.3188	11/20/2029 0:00	2150	150.5392
7/6/2029 0:00	2013	149.8685	8/21/2029 0:00	2059	150.0986	10/6/2029 0:00	2105	150.3237	11/21/2029 0:00	2151	150.5439
7/7/2029 0:00	2014	149.8735	8/22/2029 0:00	2060	150.1035	10/7/2029 0:00	2106	150.3285	11/22/2029 0:00	2152	150.5486
7/8/2029 0:00	2015	149.8786	8/23/2029 0:00	2061	150.1085	10/8/2029 0:00	2107	150.3334	11/23/2029 0:00	2153	150.5534
7/9/2029 0:00	2016	149.8836	8/24/2029 0:00	2062	150.1134	10/9/2029 0:00	2108	150.3382	11/24/2029 0:00	2154	150.5581
7/10/2029 0:00	2017	149.8887	8/25/2029 0:00	2063	150.1184	10/10/2029 0:00	2109	150.343	11/25/2029 0:00	2155	150.5628
7/11/2029 0:00	2018	149.8937	8/26/2029 0:00	2064	150.1233	10/11/2029 0:00	2110	150.3478	11/26/2029 0:00	2156	150.5675
7/12/2029 0:00	2019	149.8988	8/27/2029 0:00	2065	150.1282	10/12/2029 0:00	2111	150.3527	11/27/2029 0:00	2157	150.5723
7/13/2029 0:00	2020	149.9038	8/28/2029 0:00	2066	150.1332	10/13/2029 0:00	2112	150.3575	11/28/2029 0:00	2158	150.577
7/14/2029 0:00	2021	149.9089	8/29/2029 0:00	2067	150.1381	10/14/2029 0:00	2113	150.3623	11/29/2029 0:00	2159	150.5817
7/15/2029 0:00	2022	149.9139	8/30/2029 0:00	2068	150.143	10/15/2029 0:00	2114	150.3671	11/30/2029 0:00	2160	150.5864
7/16/2029 0:00	2023	149.9189	8/31/2029 0:00	2069	150.148	10/16/2029 0:00	2115	150.372	12/1/2029 0:00	2161	150.5911
7/17/2029 0:00	2024	149.924	9/1/2029 0:00	2070	150.1529	10/17/2029 0:00	2116	150.3768	12/2/2029 0:00	2162	150.5959
7/18/2029 0:00	2025	149.929	9/2/2029 0:00	2071	150.1578	10/18/2029 0:00	2117	150.3816	12/3/2029 0:00	2163	150.6006
7/19/2029 0:00	2026	149.934	9/3/2029 0:00	2072	150.1627	10/19/2029 0:00	2118	150.3864	12/4/2029 0:00	2164	150.6053
7/20/2029 0:00	2027	149.9391	9/4/2029 0:00	2073	150.1676	10/20/2029 0:00	2119	150.3912	12/5/2029 0:00	2165	150.61
7/21/2029 0:00	2028	149.9441	9/5/2029 0:00	2074	150.1725	10/21/2029 0:00	2120	150.396	12/6/2029 0:00	2166	150.6147
7/22/2029 0:00	2029	149.9491	9/6/2029 0:00	2075	150.1775	10/22/2029 0:00	2121	150.4008	12/7/2029 0:00	2167	150.6194
7/23/2029 0:00	2030	149.9541	9/7/2029 0:00	2076	150.1824	10/23/2029 0:00	2122	150.4056	12/8/2029 0:00	2168	150.6241
7/24/2029 0:00	2031	149.9591	9/8/2029 0:00	2077	150.1873	10/24/2029 0:00	2123	150.4104	12/9/2029 0:00	2169	150.6288
7/25/2029 0:00	2032	149.9641	9/9/2029 0:00	2078	150.1922	10/25/2029 0:00	2124	150.4152	12/10/2029 0:00	2170	150.6335
7/26/2029 0:00	2033	149.9692	9/10/2029 0:00	2079	150.1971	10/26/2029 0:00	2125	150.42	12/11/2029 0:00	2171	150.6382
7/27/2029 0:00	2034	149.9742	9/11/2029 0:00	2080	150.202	10/27/2029 0:00	2126	150.4248	12/12/2029 0:00	2172	150.6429
7/28/2029 0:00	2035	149.9792	9/12/2029 0:00	2081	150.2069	10/28/2029 0:00	2127	150.4296	12/13/2029 0:00	2173	150.6476
7/29/2029 0:00	2036	149.9842	9/13/2029 0:00	2082	150.2118	10/29/2029 0:00	2128	150.4344	12/14/2029 0:00	2174	150.6522
7/30/2029 0:00	2037	149.9892	9/14/2029 0:00	2083	150.2167	10/30/2029 0:00	2129	150.4392	12/15/2029 0:00	2175	150.6569
7/31/2029 0:00	2038	149.9942	9/15/2029 0:00	2084	150.2215	10/31/2029 0:00	2130	150.4439	12/16/2029 0:00	2176	150.6616
8/1/2029 0:00	2039	149.9992	9/16/2029 0:00	2085	150.2264	11/1/2029 0:00	2131	150.4487	12/17/2029 0:00	2177	150.6663
8/2/2029 0:00	2040	150.0042	9/17/2029 0:00	2086	150.2313	11/2/2029 0:00	2132	150.4535	12/18/2029 0:00	2178	150.671
8/3/2029 0:00	2041	150.0092	9/18/2029 0:00	2087	150.2362	11/3/2029 0:00	2133	150.4583	12/19/2029 0:00	2179	150.6756
8/4/2029 0:00	2042	150.0142	9/19/2029 0:00	2088	150.2411	11/4/2029 0:00	2134	150.4631	12/20/2029 0:00	2180	150.6803
8/5/2029 0:00	2043	150.0191	9/20/2029 0:00	2089	150.246	11/5/2029 0:00	2135	150.4678	12/21/2029 0:00	2181	150.685
8/6/2029 0:00	2044	150.0241	9/21/2029 0:00	2090	150.2508	11/6/2029 0:00	2136	150.4726	12/22/2029 0:00	2182	150.6897
8/7/2029 0:00	2045	150.0291	9/22/2029 0:00	2091	150.2557	11/7/2029 0:00	2137	150.4774	12/23/2029 0:00	2183	150.6943
8/8/2029 0:00	2046	150.0341	9/23/2029 0:00	2092	150.2606	11/8/2029 0:00	2138	150.4821	12/24/2029 0:00	2184	150.699
8/9/2029 0:00	2047	150.0391	9/24/2029 0:00	2093	150.2654	11/9/2029 0:00	2139	150.4869	12/25/2029 0:00	2185	150.7037
8/10/2029 0:00	2048	150.044	9/25/2029 0:00	2094	150.2703	11/10/2029 0:00	2140	150.4917	12/26/2029 0:00	2186	150.7083
8/11/2029 0:00	2049	150.049	9/26/2029 0:00	2095	150.2752	11/11/2029 0:00	2141	150.4964	12/27/2029 0:00	2187	150.713
8/12/2029 0:00	2050	150.054	9/27/2029 0:00	2096	150.28	11/12/2029 0:00	2142	150.5012	12/28/2029 0:00	2188	150.7176
8/13/2029 0:00	2051	150.0589	9/28/2029 0:00	2097	150.2849	11/13/2029 0:00	2143	150.5059	12/29/2029 0:00	2189	150.7223
8/14/2029 0:00	2052	150.0639	9/29/2029 0:00	2098	150.2897	11/14/2029 0:00	2144	150.5107	12/30/2029 0:00	2190	150.7269
8/15/2029 0:00	2053	150.0689	9/30/2029 0:00	2099	150.2946	11/15/2029 0:00	2145	150.5154	12/31/2029 0:00	2191	150.7316
8/16/2029 0:00	2054	150.0738	10/1/2029 0:00	2100	150.2995	11/16/2029 0:00	2146	150.5202	1/1/2030 0:00	2192	150.7362
8/17/2029 0:00	2055	150.0788	10/2/2029 0:00	2101	150.3043	11/17/2029 0:00	2147	150.5249	1/2/2030 0:00	2193	150.7409
8/18/2029 0:00	2056	150.0838	10/3/2029 0:00	2102	150.3091	11/18/2029 0:00	2148	150.5297	1/3/2030 0:00	2194	150.7455
8/19/2029 0:00	2057	150.0887	10/4/2029 0:00	2103	150.314	11/19/2029 0:00	2149	150.5344	1/4/2030 0:00	2195	150.7502

1/5/2030 0:00	2196	150.7548	2/20/2030 0:00	2242	150.966	4/7/2030 0:00	2288	151.1729	5/23/2030 0:00	2334	151.3757
1/6/2030 0:00	2197	150.7595	2/21/2030 0:00	2243	150.9706	4/8/2030 0:00	2289	151.1774	5/24/2030 0:00	2335	151.3801
1/7/2030 0:00	2198	150.7641	2/22/2030 0:00	2244	150.9751	4/9/2030 0:00	2290	151.1818	5/25/2030 0:00	2336	151.3845
1/8/2030 0:00	2199	150.7687	2/23/2030 0:00	2245	150.9796	4/10/2030 0:00	2291	151.1863	5/26/2030 0:00	2337	151.3888
1/9/2030 0:00	2200	150.7734	2/24/2030 0:00	2246	150.9842	4/11/2030 0:00	2292	151.1907	5/27/2030 0:00	2338	151.3932
1/10/2030 0:00	2201	150.778	2/25/2030 0:00	2247	150.9887	4/12/2030 0:00	2293	151.1952	5/28/2030 0:00	2339	151.3975
1/11/2030 0:00	2202	150.7826	2/26/2030 0:00	2248	150.9932	4/13/2030 0:00	2294	151.1996	5/29/2030 0:00	2340	151.4019
1/12/2030 0:00	2203	150.7872	2/27/2030 0:00	2249	150.9978	4/14/2030 0:00	2295	151.2041	5/30/2030 0:00	2341	151.4063
1/13/2030 0:00	2204	150.7919	2/28/2030 0:00	2250	151.0023	4/15/2030 0:00	2296	151.2085	5/31/2030 0:00	2342	151.4106
1/14/2030 0:00	2205	150.7965	3/1/2030 0:00	2251	151.0068	4/16/2030 0:00	2297	151.2129	6/1/2030 0:00	2343	151.415
1/15/2030 0:00	2206	150.8011	3/2/2030 0:00	2252	151.0114	4/17/2030 0:00	2298	151.2174	6/2/2030 0:00	2344	151.4193
1/16/2030 0:00	2207	150.8057	3/3/2030 0:00	2253	151.0159	4/18/2030 0:00	2299	151.2218	6/3/2030 0:00	2345	151.4236
1/17/2030 0:00	2208	150.8103	3/4/2030 0:00	2254	151.0204	4/19/2030 0:00	2300	151.2262	6/4/2030 0:00	2346	151.428
1/18/2030 0:00	2209	150.8149	3/5/2030 0:00	2255	151.0249	4/20/2030 0:00	2301	151.2307	6/5/2030 0:00	2347	151.4323
1/19/2030 0:00	2210	150.8196	3/6/2030 0:00	2256	151.0294	4/21/2030 0:00	2302	151.2351	6/6/2030 0:00	2348	151.4367
1/20/2030 0:00	2211	150.8242	3/7/2030 0:00	2257	151.034	4/22/2030 0:00	2303	151.2395	6/7/2030 0:00	2349	151.441
1/21/2030 0:00	2212	150.8288	3/8/2030 0:00	2258	151.0385	4/23/2030 0:00	2304	151.2439	6/8/2030 0:00	2350	151.4453
1/22/2030 0:00	2213	150.8334	3/9/2030 0:00	2259	151.043	4/24/2030 0:00	2305	151.2484	6/9/2030 0:00	2351	151.4497
1/23/2030 0:00	2214	150.838	3/10/2030 0:00	2260	151.0475	4/25/2030 0:00	2306	151.2528	6/10/2030 0:00	2352	151.454
1/24/2030 0:00	2215	150.8426	3/11/2030 0:00	2261	151.052	4/26/2030 0:00	2307	151.2572	6/11/2030 0:00	2353	151.4583
1/25/2030 0:00	2216	150.8472	3/12/2030 0:00	2262	151.0565	4/27/2030 0:00	2308	151.2616	6/12/2030 0:00	2354	151.4627
1/26/2030 0:00	2217	150.8518	3/13/2030 0:00	2263	151.061	4/28/2030 0:00	2309	151.266	6/13/2030 0:00	2355	151.467
1/27/2030 0:00	2218	150.8564	3/14/2030 0:00	2264	151.0655	4/29/2030 0:00	2310	151.2704	6/14/2030 0:00	2356	151.4713
1/28/2030 0:00	2219	150.861	3/15/2030 0:00	2265	151.07	4/30/2030 0:00	2311	151.2748	6/15/2030 0:00	2357	151.4757
1/29/2030 0:00	2220	150.8656	3/16/2030 0:00	2266	151.0745	5/1/2030 0:00	2312	151.2792	6/16/2030 0:00	2358	151.48
1/30/2030 0:00	2221	150.8701	3/17/2030 0:00	2267	151.079	5/2/2030 0:00	2313	151.2837	6/17/2030 0:00	2359	151.4843
1/31/2030 0:00	2222	150.8747	3/18/2030 0:00	2268	151.0835	5/3/2030 0:00	2314	151.2881	6/18/2030 0:00	2360	151.4886
2/1/2030 0:00	2223	150.8793	3/19/2030 0:00	2269	151.088	5/4/2030 0:00	2315	151.2925	6/19/2030 0:00	2361	151.4929
2/2/2030 0:00	2224	150.8839	3/20/2030 0:00	2270	151.0925	5/5/2030 0:00	2316	151.2969	6/20/2030 0:00	2362	151.4972
2/3/2030 0:00	2225	150.8885	3/21/2030 0:00	2271	151.097	5/6/2030 0:00	2317	151.3013	6/21/2030 0:00	2363	151.5016
2/4/2030 0:00	2226	150.8931	3/22/2030 0:00	2272	151.1014	5/7/2030 0:00	2318	151.3057	6/22/2030 0:00	2364	151.5059
2/5/2030 0:00	2227	150.8976	3/23/2030 0:00	2273	151.1059	5/8/2030 0:00	2319	151.31	6/23/2030 0:00	2365	151.5102
2/6/2030 0:00	2228	150.9022	3/24/2030 0:00	2274	151.1104	5/9/2030 0:00	2320	151.3144	6/24/2030 0:00	2366	151.5145
2/7/2030 0:00	2229	150.9068	3/25/2030 0:00	2275	151.1149	5/10/2030 0:00	2321	151.3188	6/25/2030 0:00	2367	151.5188
2/8/2030 0:00	2230	150.9113	3/26/2030 0:00	2276	151.1194	5/11/2030 0:00	2322	151.3232	6/26/2030 0:00	2368	151.5231
2/9/2030 0:00	2231	150.9159	3/27/2030 0:00	2277	151.1238	5/12/2030 0:00	2323	151.3276	6/27/2030 0:00	2369	151.5274
2/10/2030 0:00	2232	150.9205	3/28/2030 0:00	2278	151.1283	5/13/2030 0:00	2324	151.332	6/28/2030 0:00	2370	151.5317
2/11/2030 0:00	2233	150.925	3/29/2030 0:00	2279	151.1328	5/14/2030 0:00	2325	151.3364	6/29/2030 0:00	2371	151.536
2/12/2030 0:00	2234	150.9296	3/30/2030 0:00	2280	151.1372	5/15/2030 0:00	2326	151.3408	6/30/2030 0:00	2372	151.5403
2/13/2030 0:00	2235	150.9342	3/31/2030 0:00	2281	151.1417	5/16/2030 0:00	2327	151.3451	7/1/2030 0:00	2373	151.5446
2/14/2030 0:00	2236	150.9387	4/1/2030 0:00	2282	151.1462	5/17/2030 0:00	2328	151.3495	7/2/2030 0:00	2374	151.5489
2/15/2030 0:00	2237	150.9433	4/2/2030 0:00	2283	151.1506	5/18/2030 0:00	2329	151.3539	7/3/2030 0:00	2375	151.5532
2/16/2030 0:00	2238	150.9478	4/3/2030 0:00	2284	151.1551	5/19/2030 0:00	2330	151.3583	7/4/2030 0:00	2376	151.5575
2/17/2030 0:00	2239	150.9524	4/4/2030 0:00	2285	151.1596	5/20/2030 0:00	2331	151.3626	7/5/2030 0:00	2377	151.5617
2/18/2030 0:00	2240	150.9569	4/5/2030 0:00	2286	151.164	5/21/2030 0:00	2332	151.367	7/6/2030 0:00	2378	151.566
2/19/2030 0:00	2241	150.9615	4/6/2030 0:00	2287	151.1685	5/22/2030 0:00	2333	151.3714	7/7/2030 0:00	2379	151.5703

7/8/2030 0:00	2380	151.5746	8/23/2030 0:00	2426	151.7696	10/8/2030 0:00	2472	151.961	11/23/2030 0:00	2518	152.1489
7/9/2030 0:00	2381	151.5789	8/24/2030 0:00	2427	151.7738	10/9/2030 0:00	2473	151.9652	11/24/2030 0:00	2519	152.153
7/10/2030 0:00	2382	151.5832	8/25/2030 0:00	2428	151.778	10/10/2030 0:00	2474	151.9693	11/25/2030 0:00	2520	152.157
7/11/2030 0:00	2383	151.5874	8/26/2030 0:00	2429	151.7822	10/11/2030 0:00	2475	151.9734	11/26/2030 0:00	2521	152.161
7/12/2030 0:00	2384	151.5917	8/27/2030 0:00	2430	151.7864	10/12/2030 0:00	2476	151.9775	11/27/2030 0:00	2522	152.1651
7/13/2030 0:00	2385	151.596	8/28/2030 0:00	2431	151.7906	10/13/2030 0:00	2477	151.9816	11/28/2030 0:00	2523	152.1691
7/14/2030 0:00	2386	151.6002	8/29/2030 0:00	2432	151.7948	10/14/2030 0:00	2478	151.9857	11/29/2030 0:00	2524	152.1732
7/15/2030 0:00	2387	151.6045	8/30/2030 0:00	2433	151.799	10/15/2030 0:00	2479	151.9899	11/30/2030 0:00	2525	152.1772
7/16/2030 0:00	2388	151.6088	8/31/2030 0:00	2434	151.8032	10/16/2030 0:00	2480	151.994	12/1/2030 0:00	2526	152.1812
7/17/2030 0:00	2389	151.613	9/1/2030 0:00	2435	151.8074	10/17/2030 0:00	2481	151.9981	12/2/2030 0:00	2527	152.1853
7/18/2030 0:00	2390	151.6173	9/2/2030 0:00	2436	151.8116	10/18/2030 0:00	2482	152.0022	12/3/2030 0:00	2528	152.1893
7/19/2030 0:00	2391	151.6216	9/3/2030 0:00	2437	151.8157	10/19/2030 0:00	2483	152.0063	12/4/2030 0:00	2529	152.1933
7/20/2030 0:00	2392	151.6258	9/4/2030 0:00	2438	151.8199	10/20/2030 0:00	2484	152.0104	12/5/2030 0:00	2530	152.1974
7/21/2030 0:00	2393	151.6301	9/5/2030 0:00	2439	151.8241	10/21/2030 0:00	2485	152.0145	12/6/2030 0:00	2531	152.2014
7/22/2030 0:00	2394	151.6344	9/6/2030 0:00	2440	151.8283	10/22/2030 0:00	2486	152.0186	12/7/2030 0:00	2532	152.2054
7/23/2030 0:00	2395	151.6386	9/7/2030 0:00	2441	151.8325	10/23/2030 0:00	2487	152.0227	12/8/2030 0:00	2533	152.2094
7/24/2030 0:00	2396	151.6429	9/8/2030 0:00	2442	151.8366	10/24/2030 0:00	2488	152.0268	12/9/2030 0:00	2534	152.2135
7/25/2030 0:00	2397	151.6471	9/9/2030 0:00	2443	151.8408	10/25/2030 0:00	2489	152.0309	12/10/2030 0:00	2535	152.2175
7/26/2030 0:00	2398	151.6514	9/10/2030 0:00	2444	151.845	10/26/2030 0:00	2490	152.035	12/11/2030 0:00	2536	152.2215
7/27/2030 0:00	2399	151.6556	9/11/2030 0:00	2445	151.8491	10/27/2030 0:00	2491	152.0391	12/12/2030 0:00	2537	152.2255
7/28/2030 0:00	2400	151.6599	9/12/2030 0:00	2446	151.8533	10/28/2030 0:00	2492	152.0431	12/13/2030 0:00	2538	152.2295
7/29/2030 0:00	2401	151.6641	9/13/2030 0:00	2447	151.8575	10/29/2030 0:00	2493	152.0472	12/14/2030 0:00	2539	152.2335
7/30/2030 0:00	2402	151.6683	9/14/2030 0:00	2448	151.8616	10/30/2030 0:00	2494	152.0513	12/15/2030 0:00	2540	152.2376
7/31/2030 0:00	2403	151.6726	9/15/2030 0:00	2449	151.8658	10/31/2030 0:00	2495	152.0554	12/16/2030 0:00	2541	152.2416
8/1/2030 0:00	2404	151.6768	9/16/2030 0:00	2450	151.87	11/1/2030 0:00	2496	152.0595	12/17/2030 0:00	2542	152.2456
8/2/2030 0:00	2405	151.6811	9/17/2030 0:00	2451	151.8741	11/2/2030 0:00	2497	152.0636	12/18/2030 0:00	2543	152.2496
8/3/2030 0:00	2406	151.6853	9/18/2030 0:00	2452	151.8783	11/3/2030 0:00	2498	152.0677	12/19/2030 0:00	2544	152.2536
8/4/2030 0:00	2407	151.6895	9/19/2030 0:00	2453	151.8824	11/4/2030 0:00	2499	152.0717	12/20/2030 0:00	2545	152.2576
8/5/2030 0:00	2408	151.6938	9/20/2030 0:00	2454	151.8866	11/5/2030 0:00	2500	152.0758	12/21/2030 0:00	2546	152.2616
8/6/2030 0:00	2409	151.698	9/21/2030 0:00	2455	151.8907	11/6/2030 0:00	2501	152.0799	12/22/2030 0:00	2547	152.2656
8/7/2030 0:00	2410	151.7022	9/22/2030 0:00	2456	151.8949	11/7/2030 0:00	2502	152.084	12/23/2030 0:00	2548	152.2696
8/8/2030 0:00	2411	151.7064	9/23/2030 0:00	2457	151.899	11/8/2030 0:00	2503	152.088	12/24/2030 0:00	2549	152.2736
8/9/2030 0:00	2412	151.7107	9/24/2030 0:00	2458	151.9032	11/9/2030 0:00	2504	152.0921	12/25/2030 0:00	2550	152.2776
8/10/2030 0:00	2413	151.7149	9/25/2030 0:00	2459	151.9073	11/10/2030 0:00	2505	152.0962	12/26/2030 0:00	2551	152.2816
8/11/2030 0:00	2414	151.7191	9/26/2030 0:00	2460	151.9115	11/11/2030 0:00	2506	152.1002	12/27/2030 0:00	2552	152.2856
8/12/2030 0:00	2415	151.7233	9/27/2030 0:00	2461	151.9156	11/12/2030 0:00	2507	152.1043	12/28/2030 0:00	2553	152.2896
8/13/2030 0:00	2416	151.7276	9/28/2030 0:00	2462	151.9197	11/13/2030 0:00	2508	152.1084	12/29/2030 0:00	2554	152.2936
8/14/2030 0:00	2417	151.7318	9/29/2030 0:00	2463	151.9239	11/14/2030 0:00	2509	152.1124	12/30/2030 0:00	2555	152.2976
8/15/2030 0:00	2418	151.736	9/30/2030 0:00	2464	151.928	11/15/2030 0:00	2510	152.1165	12/31/2030 0:00	2556	152.3015
8/16/2030 0:00	2419	151.7402	10/1/2030 0:00	2465	151.9321	11/16/2030 0:00	2511	152.1205	1/1/2031 0:00	2557	152.3055
8/17/2030 0:00	2420	151.7444	10/2/2030 0:00	2466	151.9363	11/17/2030 0:00	2512	152.1246	1/2/2031 0:00	2558	152.3095
8/18/2030 0:00	2421	151.7486	10/3/2030 0:00	2467	151.9404	11/18/2030 0:00	2513	152.1287	1/3/2031 0:00	2559	152.3135
8/19/2030 0:00	2422	151.7528	10/4/2030 0:00	2468	151.9445	11/19/2030 0:00	2514	152.1327	1/4/2031 0:00	2560	152.3175
8/20/2030 0:00	2423	151.757	10/5/2030 0:00	2469	151.9487	11/20/2030 0:00	2515	152.1368	1/5/2031 0:00	2561	152.3215
8/21/2030 0:00	2424	151.7612	10/6/2030 0:00	2470	151.9528	11/21/2030 0:00	2516	152.1408	1/6/2031 0:00	2562	152.3254
8/22/2030 0:00	2425	151.7654	10/7/2030 0:00	2471	151.9569	11/22/2030 0:00	2517	152.1449	1/7/2031 0:00	2563	152.3294

1/8/2031 0:00	2564	152.3334	2/23/2031 0:00	2610	152.5146	4/10/2031 0:00	2656	152.6926	5/26/2031 0:00	2702	152.8676
1/9/2031 0:00	2565	152.3374	2/24/2031 0:00	2611	152.5185	4/11/2031 0:00	2657	152.6965	5/27/2031 0:00	2703	152.8714
1/10/2031 0:00	2566	152.3413	2/25/2031 0:00	2612	152.5224	4/12/2031 0:00	2658	152.7003	5/28/2031 0:00	2704	152.8751
1/11/2031 0:00	2567	152.3453	2/26/2031 0:00	2613	152.5263	4/13/2031 0:00	2659	152.7041	5/29/2031 0:00	2705	152.8789
1/12/2031 0:00	2568	152.3493	2/27/2031 0:00	2614	152.5302	4/14/2031 0:00	2660	152.708	5/30/2031 0:00	2706	152.8827
1/13/2031 0:00	2569	152.3532	2/28/2031 0:00	2615	152.5341	4/15/2031 0:00	2661	152.7118	5/31/2031 0:00	2707	152.8864
1/14/2031 0:00	2570	152.3572	3/1/2031 0:00	2616	152.538	4/16/2031 0:00	2662	152.7156	6/1/2031 0:00	2708	152.8902
1/15/2031 0:00	2571	152.3612	3/2/2031 0:00	2617	152.5419	4/17/2031 0:00	2663	152.7194	6/2/2031 0:00	2709	152.894
1/16/2031 0:00	2572	152.3651	3/3/2031 0:00	2618	152.5458	4/18/2031 0:00	2664	152.7233	6/3/2031 0:00	2710	152.8977
1/17/2031 0:00	2573	152.3691	3/4/2031 0:00	2619	152.5497	4/19/2031 0:00	2665	152.7271	6/4/2031 0:00	2711	152.9015
1/18/2031 0:00	2574	152.373	3/5/2031 0:00	2620	152.5536	4/20/2031 0:00	2666	152.7309	6/5/2031 0:00	2712	152.9053
1/19/2031 0:00	2575	152.377	3/6/2031 0:00	2621	152.5574	4/21/2031 0:00	2667	152.7347	6/6/2031 0:00	2713	152.909
1/20/2031 0:00	2576	152.381	3/7/2031 0:00	2622	152.5613	4/22/2031 0:00	2668	152.7386	6/7/2031 0:00	2714	152.9128
1/21/2031 0:00	2577	152.3849	3/8/2031 0:00	2623	152.5652	4/23/2031 0:00	2669	152.7424	6/8/2031 0:00	2715	152.9165
1/22/2031 0:00	2578	152.3889	3/9/2031 0:00	2624	152.5691	4/24/2031 0:00	2670	152.7462	6/9/2031 0:00	2716	152.9203
1/23/2031 0:00	2579	152.3928	3/10/2031 0:00	2625	152.573	4/25/2031 0:00	2671	152.75	6/10/2031 0:00	2717	152.924
1/24/2031 0:00	2580	152.3968	3/11/2031 0:00	2626	152.5769	4/26/2031 0:00	2672	152.7538	6/11/2031 0:00	2718	152.9278
1/25/2031 0:00	2581	152.4007	3/12/2031 0:00	2627	152.5807	4/27/2031 0:00	2673	152.7576	6/12/2031 0:00	2719	152.9315
1/26/2031 0:00	2582	152.4047	3/13/2031 0:00	2628	152.5846	4/28/2031 0:00	2674	152.7614	6/13/2031 0:00	2720	152.9353
1/27/2031 0:00	2583	152.4086	3/14/2031 0:00	2629	152.5885	4/29/2031 0:00	2675	152.7653	6/14/2031 0:00	2721	152.939
1/28/2031 0:00	2584	152.4126	3/15/2031 0:00	2630	152.5924	4/30/2031 0:00	2676	152.7691	6/15/2031 0:00	2722	152.9428
1/29/2031 0:00	2585	152.4165	3/16/2031 0:00	2631	152.5962	5/1/2031 0:00	2677	152.7729	6/16/2031 0:00	2723	152.9465
1/30/2031 0:00	2586	152.4204	3/17/2031 0:00	2632	152.6001	5/2/2031 0:00	2678	152.7767	6/17/2031 0:00	2724	152.9502
1/31/2031 0:00	2587	152.4244	3/18/2031 0:00	2633	152.604	5/3/2031 0:00	2679	152.7805	6/18/2031 0:00	2725	152.954
2/1/2031 0:00	2588	152.4283	3/19/2031 0:00	2634	152.6079	5/4/2031 0:00	2680	152.7843	6/19/2031 0:00	2726	152.9577
2/2/2031 0:00	2589	152.4323	3/20/2031 0:00	2635	152.6117	5/5/2031 0:00	2681	152.7881	6/20/2031 0:00	2727	152.9615
2/3/2031 0:00	2590	152.4362	3/21/2031 0:00	2636	152.6156	5/6/2031 0:00	2682	152.7919	6/21/2031 0:00	2728	152.9652
2/4/2031 0:00	2591	152.4401	3/22/2031 0:00	2637	152.6195	5/7/2031 0:00	2683	152.7957	6/22/2031 0:00	2729	152.9689
2/5/2031 0:00	2592	152.4441	3/23/2031 0:00	2638	152.6233	5/8/2031 0:00	2684	152.7995	6/23/2031 0:00	2730	152.9727
2/6/2031 0:00	2593	152.448	3/24/2031 0:00	2639	152.6272	5/9/2031 0:00	2685	152.8033	6/24/2031 0:00	2731	152.9764
2/7/2031 0:00	2594	152.4519	3/25/2031 0:00	2640	152.631	5/10/2031 0:00	2686	152.8071	6/25/2031 0:00	2732	152.9801
2/8/2031 0:00	2595	152.4558	3/26/2031 0:00	2641	152.6349	5/11/2031 0:00	2687	152.8109	6/26/2031 0:00	2733	152.9839
2/9/2031 0:00	2596	152.4598	3/27/2031 0:00	2642	152.6388	5/12/2031 0:00	2688	152.8147	6/27/2031 0:00	2734	152.9876
2/10/2031 0:00	2597	152.4637	3/28/2031 0:00	2643	152.6426	5/13/2031 0:00	2689	152.8185	6/28/2031 0:00	2735	152.9913
2/11/2031 0:00	2598	152.4676	3/29/2031 0:00	2644	152.6465	5/14/2031 0:00	2690	152.8222	6/29/2031 0:00	2736	152.995
2/12/2031 0:00	2599	152.4715	3/30/2031 0:00	2645	152.6503	5/15/2031 0:00	2691	152.826	6/30/2031 0:00	2737	152.9988
2/13/2031 0:00	2600	152.4755	3/31/2031 0:00	2646	152.6542	5/16/2031 0:00	2692	152.8298	7/1/2031 0:00	2738	153.0025
2/14/2031 0:00	2601	152.4794	4/1/2031 0:00	2647	152.658	5/17/2031 0:00	2693	152.8336	7/2/2031 0:00	2739	153.0062
2/15/2031 0:00	2602	152.4833	4/2/2031 0:00	2648	152.6619	5/18/2031 0:00	2694	152.8374	7/3/2031 0:00	2740	153.0099
2/16/2031 0:00	2603	152.4872	4/3/2031 0:00	2649	152.6657	5/19/2031 0:00	2695	152.8412	7/4/2031 0:00	2741	153.0136
2/17/2031 0:00	2604	152.4911	4/4/2031 0:00	2650	152.6696	5/20/2031 0:00	2696	152.8449	7/5/2031 0:00	2742	153.0174
2/18/2031 0:00	2605	152.495	4/5/2031 0:00	2651	152.6734	5/21/2031 0:00	2697	152.8487	7/6/2031 0:00	2743	153.0211
2/19/2031 0:00	2606	152.499	4/6/2031 0:00	2652	152.6773	5/22/2031 0:00	2698	152.8525	7/7/2031 0:00	2744	153.0248
2/20/2031 0:00	2607	152.5029	4/7/2031 0:00	2653	152.6811	5/23/2031 0:00	2699	152.8563	7/8/2031 0:00	2745	153.0285
2/21/2031 0:00	2608	152.5068	4/8/2031 0:00	2654	152.6849	5/24/2031 0:00	2700	152.8601	7/9/2031 0:00	2746	153.0322
2/22/2031 0:00	2609	152.5107	4/9/2031 0:00	2655	152.6888	5/25/2031 0:00	2701	152.8638	7/10/2031 0:00	2747	153.0359

7/11/2031 0:00	2748	153.0396	8/26/2031 0:00	2794	153.2088	10/11/2031 0:00	2840	153.3752	11/26/2031 0:00	2886	153.539
7/12/2031 0:00	2749	153.0433	8/27/2031 0:00	2795	153.2125	10/12/2031 0:00	2841	153.3788	11/27/2031 0:00	2887	153.5425
7/13/2031 0:00	2750	153.0471	8/28/2031 0:00	2796	153.2161	10/13/2031 0:00	2842	153.3824	11/28/2031 0:00	2888	153.5461
7/14/2031 0:00	2751	153.0508	8/29/2031 0:00	2797	153.2198	10/14/2031 0:00	2843	153.386	11/29/2031 0:00	2889	153.5496
7/15/2031 0:00	2752	153.0545	8/30/2031 0:00	2798	153.2234	10/15/2031 0:00	2844	153.3896	11/30/2031 0:00	2890	153.5531
7/16/2031 0:00	2753	153.0582	8/31/2031 0:00	2799	153.227	10/16/2031 0:00	2845	153.3932	12/1/2031 0:00	2891	153.5566
7/17/2031 0:00	2754	153.0619	9/1/2031 0:00	2800	153.2307	10/17/2031 0:00	2846	153.3968	12/2/2031 0:00	2892	153.5602
7/18/2031 0:00	2755	153.0656	9/2/2031 0:00	2801	153.2343	10/18/2031 0:00	2847	153.4003	12/3/2031 0:00	2893	153.5637
7/19/2031 0:00	2756	153.0693	9/3/2031 0:00	2802	153.238	10/19/2031 0:00	2848	153.4039	12/4/2031 0:00	2894	153.5672
7/20/2031 0:00	2757	153.073	9/4/2031 0:00	2803	153.2416	10/20/2031 0:00	2849	153.4075	12/5/2031 0:00	2895	153.5707
7/21/2031 0:00	2758	153.0767	9/5/2031 0:00	2804	153.2452	10/21/2031 0:00	2850	153.4111	12/6/2031 0:00	2896	153.5743
7/22/2031 0:00	2759	153.0804	9/6/2031 0:00	2805	153.2489	10/22/2031 0:00	2851	153.4146	12/7/2031 0:00	2897	153.5778
7/23/2031 0:00	2760	153.084	9/7/2031 0:00	2806	153.2525	10/23/2031 0:00	2852	153.4182	12/8/2031 0:00	2898	153.5813
7/24/2031 0:00	2761	153.0877	9/8/2031 0:00	2807	153.2561	10/24/2031 0:00	2853	153.4218	12/9/2031 0:00	2899	153.5848
7/25/2031 0:00	2762	153.0914	9/9/2031 0:00	2808	153.2598	10/25/2031 0:00	2854	153.4254	12/10/2031 0:00	2900	153.5883
7/26/2031 0:00	2763	153.0951	9/10/2031 0:00	2809	153.2634	10/26/2031 0:00	2855	153.4289	12/11/2031 0:00	2901	153.5918
7/27/2031 0:00	2764	153.0988	9/11/2031 0:00	2810	153.267	10/27/2031 0:00	2856	153.4325	12/12/2031 0:00	2902	153.5953
7/28/2031 0:00	2765	153.1025	9/12/2031 0:00	2811	153.2706	10/28/2031 0:00	2857	153.4361	12/13/2031 0:00	2903	153.5989
7/29/2031 0:00	2766	153.1062	9/13/2031 0:00	2812	153.2743	10/29/2031 0:00	2858	153.4396	12/14/2031 0:00	2904	153.6024
7/30/2031 0:00	2767	153.1099	9/14/2031 0:00	2813	153.2779	10/30/2031 0:00	2859	153.4432	12/15/2031 0:00	2905	153.6059
7/31/2031 0:00	2768	153.1135	9/15/2031 0:00	2814	153.2815	10/31/2031 0:00	2860	153.4468	12/16/2031 0:00	2906	153.6094
8/1/2031 0:00	2769	153.1172	9/16/2031 0:00	2815	153.2851	11/1/2031 0:00	2861	153.4503	12/17/2031 0:00	2907	153.6129
8/2/2031 0:00	2770	153.1209	9/17/2031 0:00	2816	153.2888	11/2/2031 0:00	2862	153.4539	12/18/2031 0:00	2908	153.6164
8/3/2031 0:00	2771	153.1246	9/18/2031 0:00	2817	153.2924	11/3/2031 0:00	2863	153.4575	12/19/2031 0:00	2909	153.6199
8/4/2031 0:00	2772	153.1283	9/19/2031 0:00	2818	153.296	11/4/2031 0:00	2864	153.461	12/20/2031 0:00	2910	153.6234
8/5/2031 0:00	2773	153.1319	9/20/2031 0:00	2819	153.2996	11/5/2031 0:00	2865	153.4646	12/21/2031 0:00	2911	153.6269
8/6/2031 0:00	2774	153.1356	9/21/2031 0:00	2820	153.3032	11/6/2031 0:00	2866	153.4681	12/22/2031 0:00	2912	153.6304
8/7/2031 0:00	2775	153.1393	9/22/2031 0:00	2821	153.3068	11/7/2031 0:00	2867	153.4717	12/23/2031 0:00	2913	153.6339
8/8/2031 0:00	2776	153.143	9/23/2031 0:00	2822	153.3104	11/8/2031 0:00	2868	153.4752	12/24/2031 0:00	2914	153.6374
8/9/2031 0:00	2777	153.1466	9/24/2031 0:00	2823	153.3141	11/9/2031 0:00	2869	153.4788	12/25/2031 0:00	2915	153.6409
8/10/2031 0:00	2778	153.1503	9/25/2031 0:00	2824	153.3177	11/10/2031 0:00	2870	153.4823	12/26/2031 0:00	2916	153.6444
8/11/2031 0:00	2779	153.154	9/26/2031 0:00	2825	153.3213	11/11/2031 0:00	2871	153.4859	12/27/2031 0:00	2917	153.6479
8/12/2031 0:00	2780	153.1576	9/27/2031 0:00	2826	153.3249	11/12/2031 0:00	2872	153.4894	12/28/2031 0:00	2918	153.6514
8/13/2031 0:00	2781	153.1613	9/28/2031 0:00	2827	153.3285	11/13/2031 0:00	2873	153.493	12/29/2031 0:00	2919	153.6549
8/14/2031 0:00	2782	153.165	9/29/2031 0:00	2828	153.3321	11/14/2031 0:00	2874	153.4965	12/30/2031 0:00	2920	153.6584
8/15/2031 0:00	2783	153.1686	9/30/2031 0:00	2829	153.3357	11/15/2031 0:00	2875	153.5001	12/31/2031 0:00	2921	153.6619
8/16/2031 0:00	2784	153.1723	10/1/2031 0:00	2830	153.3393	11/16/2031 0:00	2876	153.5036	1/1/2032 0:00	2922	153.6653
8/17/2031 0:00	2785	153.1759	10/2/2031 0:00	2831	153.3429	11/17/2031 0:00	2877	153.5072	1/2/2032 0:00	2923	153.6688
8/18/2031 0:00	2786	153.1796	10/3/2031 0:00	2832	153.3465	11/18/2031 0:00	2878	153.5107	1/3/2032 0:00	2924	153.6723
8/19/2031 0:00	2787	153.1833	10/4/2031 0:00	2833	153.3501	11/19/2031 0:00	2879	153.5142	1/4/2032 0:00	2925	153.6758
8/20/2031 0:00	2788	153.1869	10/5/2031 0:00	2834	153.3537	11/20/2031 0:00	2880	153.5178	1/5/2032 0:00	2926	153.6793
8/21/2031 0:00	2789	153.1906	10/6/2031 0:00	2835	153.3573	11/21/2031 0:00	2881	153.5213	1/6/2032 0:00	2927	153.6828
8/22/2031 0:00	2790	153.1942	10/7/2031 0:00	2836	153.3609	11/22/2031 0:00	2882	153.5249	1/7/2032 0:00	2928	153.6863
8/23/2031 0:00	2791	153.1979	10/8/2031 0:00	2837	153.3645	11/23/2031 0:00	2883	153.5284	1/8/2032 0:00	2929	153.6897
8/24/2031 0:00	2792	153.2015	10/9/2031 0:00	2838	153.3681	11/24/2031 0:00	2884	153.5319	1/9/2032 0:00	2930	153.6932
8/25/2031 0:00	2793	153.2052	10/10/2031 0:00	2839	153.3717	11/25/2031 0:00	2885	153.5355	1/10/2032 0:00	2931	153.6967

1/11/2032 0:00	2932	153.7002	2/26/2032 0:00	2978	153.8588	4/12/2032 0:00	3024	154.0151	5/28/2032 0:00	3070	154.1689
1/12/2032 0:00	2933	153.7036	2/27/2032 0:00	2979	153.8622	4/13/2032 0:00	3025	154.0184	5/29/2032 0:00	3071	154.1723
1/13/2032 0:00	2934	153.7071	2/28/2032 0:00	2980	153.8657	4/14/2032 0:00	3026	154.0218	5/30/2032 0:00	3072	154.1756
1/14/2032 0:00	2935	153.7106	2/29/2032 0:00	2981	153.8691	4/15/2032 0:00	3027	154.0252	5/31/2032 0:00	3073	154.1789
1/15/2032 0:00	2936	153.7141	3/1/2032 0:00	2982	153.8725	4/16/2032 0:00	3028	154.0285	6/1/2032 0:00	3074	154.1822
1/16/2032 0:00	2937	153.7175	3/2/2032 0:00	2983	153.8759	4/17/2032 0:00	3029	154.0319	6/2/2032 0:00	3075	154.1855
1/17/2032 0:00	2938	153.721	3/3/2032 0:00	2984	153.8793	4/18/2032 0:00	3030	154.0353	6/3/2032 0:00	3076	154.1888
1/18/2032 0:00	2939	153.7245	3/4/2032 0:00	2985	153.8828	4/19/2032 0:00	3031	154.0386	6/4/2032 0:00	3077	154.1921
1/19/2032 0:00	2940	153.7279	3/5/2032 0:00	2986	153.8862	4/20/2032 0:00	3032	154.042	6/5/2032 0:00	3078	154.1955
1/20/2032 0:00	2941	153.7314	3/6/2032 0:00	2987	153.8896	4/21/2032 0:00	3033	154.0453	6/6/2032 0:00	3079	154.1988
1/21/2032 0:00	2942	153.7349	3/7/2032 0:00	2988	153.893	4/22/2032 0:00	3034	154.0487	6/7/2032 0:00	3080	154.2021
1/22/2032 0:00	2943	153.7383	3/8/2032 0:00	2989	153.8964	4/23/2032 0:00	3035	154.0521	6/8/2032 0:00	3081	154.2054
1/23/2032 0:00	2944	153.7418	3/9/2032 0:00	2990	153.8998	4/24/2032 0:00	3036	154.0554	6/9/2032 0:00	3082	154.2087
1/24/2032 0:00	2945	153.7453	3/10/2032 0:00	2991	153.9032	4/25/2032 0:00	3037	154.0588	6/10/2032 0:00	3083	154.212
1/25/2032 0:00	2946	153.7487	3/11/2032 0:00	2992	153.9066	4/26/2032 0:00	3038	154.0621	6/11/2032 0:00	3084	154.2153
1/26/2032 0:00	2947	153.7522	3/12/2032 0:00	2993	153.91	4/27/2032 0:00	3039	154.0655	6/12/2032 0:00	3085	154.2186
1/27/2032 0:00	2948	153.7556	3/13/2032 0:00	2994	153.9134	4/28/2032 0:00	3040	154.0688	6/13/2032 0:00	3086	154.2219
1/28/2032 0:00	2949	153.7591	3/14/2032 0:00	2995	153.9168	4/29/2032 0:00	3041	154.0722	6/14/2032 0:00	3087	154.2252
1/29/2032 0:00	2950	153.7625	3/15/2032 0:00	2996	153.9202	4/30/2032 0:00	3042	154.0755	6/15/2032 0:00	3088	154.2285
1/30/2032 0:00	2951	153.766	3/16/2032 0:00	2997	153.9236	5/1/2032 0:00	3043	154.0789	6/16/2032 0:00	3089	154.2318
1/31/2032 0:00	2952	153.7695	3/17/2032 0:00	2998	153.927	5/2/2032 0:00	3044	154.0822	6/17/2032 0:00	3090	154.2351
2/1/2032 0:00	2953	153.7729	3/18/2032 0:00	2999	153.9304	5/3/2032 0:00	3045	154.0856	6/18/2032 0:00	3091	154.2384
2/2/2032 0:00	2954	153.7764	3/19/2032 0:00	3000	153.9338	5/4/2032 0:00	3046	154.0889	6/19/2032 0:00	3092	154.2417
2/3/2032 0:00	2955	153.7798	3/20/2032 0:00	3001	153.9372	5/5/2032 0:00	3047	154.0923	6/20/2032 0:00	3093	154.245
2/4/2032 0:00	2956	153.7833	3/21/2032 0:00	3002	153.9406	5/6/2032 0:00	3048	154.0956	6/21/2032 0:00	3094	154.2483
2/5/2032 0:00	2957	153.7867	3/22/2032 0:00	3003	153.944	5/7/2032 0:00	3049	154.099	6/22/2032 0:00	3095	154.2516
2/6/2032 0:00	2958	153.7901	3/23/2032 0:00	3004	153.9474	5/8/2032 0:00	3050	154.1023	6/23/2032 0:00	3096	154.2549
2/7/2032 0:00	2959	153.7936	3/24/2032 0:00	3005	153.9508	5/9/2032 0:00	3051	154.1057	6/24/2032 0:00	3097	154.2582
2/8/2032 0:00	2960	153.797	3/25/2032 0:00	3006	153.9542	5/10/2032 0:00	3052	154.109	6/25/2032 0:00	3098	154.2615
2/9/2032 0:00	2961	153.8005	3/26/2032 0:00	3007	153.9576	5/11/2032 0:00	3053	154.1123	6/26/2032 0:00	3099	154.2648
2/10/2032 0:00	2962	153.8039	3/27/2032 0:00	3008	153.961	5/12/2032 0:00	3054	154.1157	6/27/2032 0:00	3100	154.2681
2/11/2032 0:00	2963	153.8074	3/28/2032 0:00	3009	153.9644	5/13/2032 0:00	3055	154.119	6/28/2032 0:00	3101	154.2713
2/12/2032 0:00	2964	153.8108	3/29/2032 0:00	3010	153.9678	5/14/2032 0:00	3056	154.1223	6/29/2032 0:00	3102	154.2746
2/13/2032 0:00	2965	153.8142	3/30/2032 0:00	3011	153.9711	5/15/2032 0:00	3057	154.1257	6/30/2032 0:00	3103	154.2779
2/14/2032 0:00	2966	153.8177	3/31/2032 0:00	3012	153.9745	5/16/2032 0:00	3058	154.129	7/1/2032 0:00	3104	154.2812
2/15/2032 0:00	2967	153.8211	4/1/2032 0:00	3013	153.9779	5/17/2032 0:00	3059	154.1323	7/2/2032 0:00	3105	154.2845
2/16/2032 0:00	2968	153.8245	4/2/2032 0:00	3014	153.9813	5/18/2032 0:00	3060	154.1357	7/3/2032 0:00	3106	154.2878
2/17/2032 0:00	2969	153.828	4/3/2032 0:00	3015	153.9847	5/19/2032 0:00	3061	154.139	7/4/2032 0:00	3107	154.291
2/18/2032 0:00	2970	153.8314	4/4/2032 0:00	3016	153.9881	5/20/2032 0:00	3062	154.1423	7/5/2032 0:00	3108	154.2943
2/19/2032 0:00	2971	153.8348	4/5/2032 0:00	3017	153.9914	5/21/2032 0:00	3063	154.1457	7/6/2032 0:00	3109	154.2976
2/20/2032 0:00	2972	153.8383	4/6/2032 0:00	3018	153.9948	5/22/2032 0:00	3064	154.149	7/7/2032 0:00	3110	154.3009
2/21/2032 0:00	2973	153.8417	4/7/2032 0:00	3019	153.9982	5/23/2032 0:00	3065	154.1523	7/8/2032 0:00	3111	154.3042
2/22/2032 0:00	2974	153.8451	4/8/2032 0:00	3020	154.0016	5/24/2032 0:00	3066	154.1556	7/9/2032 0:00	3112	154.3074
2/23/2032 0:00	2975	153.8486	4/9/2032 0:00	3021	154.0049	5/25/2032 0:00	3067	154.159	7/10/2032 0:00	3113	154.3107
2/24/2032 0:00	2976	153.852	4/10/2032 0:00	3022	154.0083	5/26/2032 0:00	3068	154.1623	7/11/2032 0:00	3114	154.314
2/25/2032 0:00	2977	153.8554	4/11/2032 0:00	3023	154.0117	5/27/2032 0:00	3069	154.1656	7/12/2032 0:00	3115	154.3173

7/13/2032 0:00	3116	154.3205	8/28/2032 0:00	3162	154.4699	10/13/2032 0:00	3208	154.6171	11/28/2032 0:00	3254	154.7622
7/14/2032 0:00	3117	154.3238	8/29/2032 0:00	3163	154.4731	10/14/2032 0:00	3209	154.6203	11/29/2032 0:00	3255	154.7654
7/15/2032 0:00	3118	154.3271	8/30/2032 0:00	3164	154.4763	10/15/2032 0:00	3210	154.6235	11/30/2032 0:00	3256	154.7685
7/16/2032 0:00	3119	154.3303	8/31/2032 0:00	3165	154.4796	10/16/2032 0:00	3211	154.6266	12/1/2032 0:00	3257	154.7716
7/17/2032 0:00	3120	154.3336	9/1/2032 0:00	3166	154.4828	10/17/2032 0:00	3212	154.6298	12/2/2032 0:00	3258	154.7748
7/18/2032 0:00	3121	154.3369	9/2/2032 0:00	3167	154.486	10/18/2032 0:00	3213	154.633	12/3/2032 0:00	3259	154.7779
7/19/2032 0:00	3122	154.3401	9/3/2032 0:00	3168	154.4892	10/19/2032 0:00	3214	154.6362	12/4/2032 0:00	3260	154.781
7/20/2032 0:00	3123	154.3434	9/4/2032 0:00	3169	154.4924	10/20/2032 0:00	3215	154.6393	12/5/2032 0:00	3261	154.7841
7/21/2032 0:00	3124	154.3467	9/5/2032 0:00	3170	154.4957	10/21/2032 0:00	3216	154.6425	12/6/2032 0:00	3262	154.7873
7/22/2032 0:00	3125	154.3499	9/6/2032 0:00	3171	154.4989	10/22/2032 0:00	3217	154.6457	12/7/2032 0:00	3263	154.7904
7/23/2032 0:00	3126	154.3532	9/7/2032 0:00	3172	154.5021	10/23/2032 0:00	3218	154.6488	12/8/2032 0:00	3264	154.7935
7/24/2032 0:00	3127	154.3564	9/8/2032 0:00	3173	154.5053	10/24/2032 0:00	3219	154.652	12/9/2032 0:00	3265	154.7966
7/25/2032 0:00	3128	154.3597	9/9/2032 0:00	3174	154.5085	10/25/2032 0:00	3220	154.6552	12/10/2032 0:00	3266	154.7998
7/26/2032 0:00	3129	154.363	9/10/2032 0:00	3175	154.5117	10/26/2032 0:00	3221	154.6583	12/11/2032 0:00	3267	154.8029
7/27/2032 0:00	3130	154.3662	9/11/2032 0:00	3176	154.5149	10/27/2032 0:00	3222	154.6615	12/12/2032 0:00	3268	154.806
7/28/2032 0:00	3131	154.3695	9/12/2032 0:00	3177	154.5181	10/28/2032 0:00	3223	154.6647	12/13/2032 0:00	3269	154.8091
7/29/2032 0:00	3132	154.3727	9/13/2032 0:00	3178	154.5213	10/29/2032 0:00	3224	154.6678	12/14/2032 0:00	3270	154.8122
7/30/2032 0:00	3133	154.376	9/14/2032 0:00	3179	154.5246	10/30/2032 0:00	3225	154.671	12/15/2032 0:00	3271	154.8154
7/31/2032 0:00	3134	154.3792	9/15/2032 0:00	3180	154.5278	10/31/2032 0:00	3226	154.6741	12/16/2032 0:00	3272	154.8185
8/1/2032 0:00	3135	154.3825	9/16/2032 0:00	3181	154.531	11/1/2032 0:00	3227	154.6773	12/17/2032 0:00	3273	154.8216
8/2/2032 0:00	3136	154.3857	9/17/2032 0:00	3182	154.5342	11/2/2032 0:00	3228	154.6805	12/18/2032 0:00	3274	154.8247
8/3/2032 0:00	3137	154.389	9/18/2032 0:00	3183	154.5374	11/3/2032 0:00	3229	154.6836	12/19/2032 0:00	3275	154.8278
8/4/2032 0:00	3138	154.3922	9/19/2032 0:00	3184	154.5406	11/4/2032 0:00	3230	154.6868	12/20/2032 0:00	3276	154.8309
8/5/2032 0:00	3139	154.3955	9/20/2032 0:00	3185	154.5438	11/5/2032 0:00	3231	154.6899	12/21/2032 0:00	3277	154.834
8/6/2032 0:00	3140	154.3987	9/21/2032 0:00	3186	154.547	11/6/2032 0:00	3232	154.6931	12/22/2032 0:00	3278	154.8371
8/7/2032 0:00	3141	154.402	9/22/2032 0:00	3187	154.5502	11/7/2032 0:00	3233	154.6962	12/23/2032 0:00	3279	154.8403
8/8/2032 0:00	3142	154.4052	9/23/2032 0:00	3188	154.5534	11/8/2032 0:00	3234	154.6994	12/24/2032 0:00	3280	154.8434
8/9/2032 0:00	3143	154.4085	9/24/2032 0:00	3189	154.5566	11/9/2032 0:00	3235	154.7025	12/25/2032 0:00	3281	154.8465
8/10/2032 0:00	3144	154.4117	9/25/2032 0:00	3190	154.5598	11/10/2032 0:00	3236	154.7057	12/26/2032 0:00	3282	154.8496
8/11/2032 0:00	3145	154.4149	9/26/2032 0:00	3191	154.563	11/11/2032 0:00	3237	154.7088	12/27/2032 0:00	3283	154.8527
8/12/2032 0:00	3146	154.4182	9/27/2032 0:00	3192	154.5661	11/12/2032 0:00	3238	154.712	12/28/2032 0:00	3284	154.8558
8/13/2032 0:00	3147	154.4214	9/28/2032 0:00	3193	154.5693	11/13/2032 0:00	3239	154.7151	12/29/2032 0:00	3285	154.8589
8/14/2032 0:00	3148	154.4247	9/29/2032 0:00	3194	154.5725	11/14/2032 0:00	3240	154.7183	12/30/2032 0:00	3286	154.862
8/15/2032 0:00	3149	154.4279	9/30/2032 0:00	3195	154.5757	11/15/2032 0:00	3241	154.7214	12/31/2032 0:00	3287	154.8651
8/16/2032 0:00	3150	154.4311	10/1/2032 0:00	3196	154.5789	11/16/2032 0:00	3242	154.7246	1/1/2033 0:00	3288	154.8682
8/17/2032 0:00	3151	154.4344	10/2/2032 0:00	3197	154.5821	11/17/2032 0:00	3243	154.7277	1/2/2033 0:00	3289	154.8713
8/18/2032 0:00	3152	154.4376	10/3/2032 0:00	3198	154.5853	11/18/2032 0:00	3244	154.7309	1/3/2033 0:00	3290	154.8744
8/19/2032 0:00	3153	154.4408	10/4/2032 0:00	3199	154.5885	11/19/2032 0:00	3245	154.734	1/4/2033 0:00	3291	154.8775
8/20/2032 0:00	3154	154.4441	10/5/2032 0:00	3200	154.5917	11/20/2032 0:00	3246	154.7371	1/5/2033 0:00	3292	154.8806
8/21/2032 0:00	3155	154.4473	10/6/2032 0:00	3201	154.5948	11/21/2032 0:00	3247	154.7403	1/6/2033 0:00	3293	154.8837
8/22/2032 0:00	3156	154.4505	10/7/2032 0:00	3202	154.598	11/22/2032 0:00	3248	154.7434	1/7/2033 0:00	3294	154.8868
8/23/2032 0:00	3157	154.4538	10/8/2032 0:00	3203	154.6012	11/23/2032 0:00	3249	154.7466	1/8/2033 0:00	3295	154.8899
8/24/2032 0:00	3158	154.457	10/9/2032 0:00	3204	154.6044	11/24/2032 0:00	3250	154.7497	1/9/2033 0:00	3296	154.893
8/25/2032 0:00	3159	154.4602	10/10/2032 0:00	3205	154.6076	11/25/2032 0:00	3251	154.7528	1/10/2033 0:00	3297	154.8961
8/26/2032 0:00	3160	154.4634	10/11/2032 0:00	3206	154.6108	11/26/2032 0:00	3252	154.756	1/11/2033 0:00	3298	154.8991
8/27/2032 0:00	3161	154.4667	10/12/2032 0:00	3207	154.6139	11/27/2032 0:00	3253	154.7591	1/12/2033 0:00	3299	154.9022

1/13/2033 0:00	3300	154.9053	2/28/2033 0:00	3346	155.0464	4/15/2033 0:00	3392	155.1856	5/31/2033 0:00	3438	155.3229
1/14/2033 0:00	3301	154.9084	3/1/2033 0:00	3347	155.0495	4/16/2033 0:00	3393	155.1886	6/1/2033 0:00	3439	155.3259
1/15/2033 0:00	3302	154.9115	3/2/2033 0:00	3348	155.0525	4/17/2033 0:00	3394	155.1916	6/2/2033 0:00	3440	155.3289
1/16/2033 0:00	3303	154.9146	3/3/2033 0:00	3349	155.0556	4/18/2033 0:00	3395	155.1946	6/3/2033 0:00	3441	155.3318
1/17/2033 0:00	3304	154.9177	3/4/2033 0:00	3350	155.0586	4/19/2033 0:00	3396	155.1976	6/4/2033 0:00	3442	155.3348
1/18/2033 0:00	3305	154.9208	3/5/2033 0:00	3351	155.0617	4/20/2033 0:00	3397	155.2006	6/5/2033 0:00	3443	155.3377
1/19/2033 0:00	3306	154.9238	3/6/2033 0:00	3352	155.0647	4/21/2033 0:00	3398	155.2036	6/6/2033 0:00	3444	155.3407
1/20/2033 0:00	3307	154.9269	3/7/2033 0:00	3353	155.0677	4/22/2033 0:00	3399	155.2066	6/7/2033 0:00	3445	155.3437
1/21/2033 0:00	3308	154.93	3/8/2033 0:00	3354	155.0708	4/23/2033 0:00	3400	155.2096	6/8/2033 0:00	3446	155.3466
1/22/2033 0:00	3309	154.9331	3/9/2033 0:00	3355	155.0738	4/24/2033 0:00	3401	155.2126	6/9/2033 0:00	3447	155.3496
1/23/2033 0:00	3310	154.9362	3/10/2033 0:00	3356	155.0769	4/25/2033 0:00	3402	155.2156	6/10/2033 0:00	3448	155.3525
1/24/2033 0:00	3311	154.9392	3/11/2033 0:00	3357	155.0799	4/26/2033 0:00	3403	155.2186	6/11/2033 0:00	3449	155.3555
1/25/2033 0:00	3312	154.9423	3/12/2033 0:00	3358	155.0829	4/27/2033 0:00	3404	155.2216	6/12/2033 0:00	3450	155.3585
1/26/2033 0:00	3313	154.9454	3/13/2033 0:00	3359	155.086	4/28/2033 0:00	3405	155.2246	6/13/2033 0:00	3451	155.3614
1/27/2033 0:00	3314	154.9485	3/14/2033 0:00	3360	155.089	4/29/2033 0:00	3406	155.2276	6/14/2033 0:00	3452	155.3644
1/28/2033 0:00	3315	154.9516	3/15/2033 0:00	3361	155.092	4/30/2033 0:00	3407	155.2306	6/15/2033 0:00	3453	155.3673
1/29/2033 0:00	3316	154.9546	3/16/2033 0:00	3362	155.0951	5/1/2033 0:00	3408	155.2336	6/16/2033 0:00	3454	155.3703
1/30/2033 0:00	3317	154.9577	3/17/2033 0:00	3363	155.0981	5/2/2033 0:00	3409	155.2366	6/17/2033 0:00	3455	155.3732
1/31/2033 0:00	3318	154.9608	3/18/2033 0:00	3364	155.1011	5/3/2033 0:00	3410	155.2396	6/18/2033 0:00	3456	155.3762
2/1/2033 0:00	3319	154.9638	3/19/2033 0:00	3365	155.1042	5/4/2033 0:00	3411	155.2426	6/19/2033 0:00	3457	155.3791
2/2/2033 0:00	3320	154.9669	3/20/2033 0:00	3366	155.1072	5/5/2033 0:00	3412	155.2455	6/20/2033 0:00	3458	155.3821
2/3/2033 0:00	3321	154.97	3/21/2033 0:00	3367	155.1102	5/6/2033 0:00	3413	155.2485	6/21/2033 0:00	3459	155.385
2/4/2033 0:00	3322	154.9731	3/22/2033 0:00	3368	155.1132	5/7/2033 0:00	3414	155.2515	6/22/2033 0:00	3460	155.388
2/5/2033 0:00	3323	154.9761	3/23/2033 0:00	3369	155.1163	5/8/2033 0:00	3415	155.2545	6/23/2033 0:00	3461	155.3909
2/6/2033 0:00	3324	154.9792	3/24/2033 0:00	3370	155.1193	5/9/2033 0:00	3416	155.2575	6/24/2033 0:00	3462	155.3938
2/7/2033 0:00	3325	154.9823	3/25/2033 0:00	3371	155.1223	5/10/2033 0:00	3417	155.2605	6/25/2033 0:00	3463	155.3968
2/8/2033 0:00	3326	154.9853	3/26/2033 0:00	3372	155.1253	5/11/2033 0:00	3418	155.2635	6/26/2033 0:00	3464	155.3997
2/9/2033 0:00	3327	154.9884	3/27/2033 0:00	3373	155.1284	5/12/2033 0:00	3419	155.2664	6/27/2033 0:00	3465	155.4027
2/10/2033 0:00	3328	154.9915	3/28/2033 0:00	3374	155.1314	5/13/2033 0:00	3420	155.2694	6/28/2033 0:00	3466	155.4056
2/11/2033 0:00	3329	154.9945	3/29/2033 0:00	3375	155.1344	5/14/2033 0:00	3421	155.2724	6/29/2033 0:00	3467	155.4086
2/12/2033 0:00	3330	154.9976	3/30/2033 0:00	3376	155.1374	5/15/2033 0:00	3422	155.2754	6/30/2033 0:00	3468	155.4115
2/13/2033 0:00	3331	155.0006	3/31/2033 0:00	3377	155.1404	5/16/2033 0:00	3423	155.2784	7/1/2033 0:00	3469	155.4144
2/14/2033 0:00	3332	155.0037	4/1/2033 0:00	3378	155.1435	5/17/2033 0:00	3424	155.2813	7/2/2033 0:00	3470	155.4174
2/15/2033 0:00	3333	155.0068	4/2/2033 0:00	3379	155.1465	5/18/2033 0:00	3425	155.2843	7/3/2033 0:00	3471	155.4203
2/16/2033 0:00	3334	155.0098	4/3/2033 0:00	3380	155.1495	5/19/2033 0:00	3426	155.2873	7/4/2033 0:00	3472	155.4233
2/17/2033 0:00	3335	155.0129	4/4/2033 0:00	3381	155.1525	5/20/2033 0:00	3427	155.2903	7/5/2033 0:00	3473	155.4262
2/18/2033 0:00	3336	155.0159	4/5/2033 0:00	3382	155.1555	5/21/2033 0:00	3428	155.2932	7/6/2033 0:00	3474	155.4291
2/19/2033 0:00	3337	155.019	4/6/2033 0:00	3383	155.1585	5/22/2033 0:00	3429	155.2962	7/7/2033 0:00	3475	155.4321
2/20/2033 0:00	3338	155.022	4/7/2033 0:00	3384	155.1616	5/23/2033 0:00	3430	155.2992	7/8/2033 0:00	3476	155.435
2/21/2033 0:00	3339	155.0251	4/8/2033 0:00	3385	155.1646	5/24/2033 0:00	3431	155.3022	7/9/2033 0:00	3477	155.4379
2/22/2033 0:00	3340	155.0281	4/9/2033 0:00	3386	155.1676	5/25/2033 0:00	3432	155.3051	7/10/2033 0:00	3478	155.4409
2/23/2033 0:00	3341	155.0312	4/10/2033 0:00	3387	155.1706	5/26/2033 0:00	3433	155.3081	7/11/2033 0:00	3479	155.4438
2/24/2033 0:00	3342	155.0342	4/11/2033 0:00	3388	155.1736	5/27/2033 0:00	3434	155.3111	7/12/2033 0:00	3480	155.4467
2/25/2033 0:00	3343	155.0373	4/12/2033 0:00	3389	155.1766	5/28/2033 0:00	3435	155.314	7/13/2033 0:00	3481	155.4496
2/26/2033 0:00	3344	155.0403	4/13/2033 0:00	3390	155.1796	5/29/2033 0:00	3436	155.317	7/14/2033 0:00	3482	155.4526
2/27/2033 0:00	3345	155.0434	4/14/2033 0:00	3391	155.1826	5/30/2033 0:00	3437	155.32	7/15/2033 0:00	3483	155.4555

7/16/2033 0:00	3484	155.4584	8/31/2033 0:00	3530	155.5921	10/16/2033 0:00	3576	155.7241	12/1/2033 0:00	3622	155.8544
7/17/2033 0:00	3485	155.4613	9/1/2033 0:00	3531	155.595	10/17/2033 0:00	3577	155.727	12/2/2033 0:00	3623	155.8572
7/18/2033 0:00	3486	155.4643	9/2/2033 0:00	3532	155.5979	10/18/2033 0:00	3578	155.7298	12/3/2033 0:00	3624	155.86
7/19/2033 0:00	3487	155.4672	9/3/2033 0:00	3533	155.6008	10/19/2033 0:00	3579	155.7327	12/4/2033 0:00	3625	155.8629
7/20/2033 0:00	3488	155.4701	9/4/2033 0:00	3534	155.6037	10/20/2033 0:00	3580	155.7355	12/5/2033 0:00	3626	155.8657
7/21/2033 0:00	3489	155.473	9/5/2033 0:00	3535	155.6066	10/21/2033 0:00	3581	155.7384	12/6/2033 0:00	3627	155.8685
7/22/2033 0:00	3490	155.476	9/6/2033 0:00	3536	155.6094	10/22/2033 0:00	3582	155.7412	12/7/2033 0:00	3628	155.8713
7/23/2033 0:00	3491	155.4789	9/7/2033 0:00	3537	155.6123	10/23/2033 0:00	3583	155.7441	12/8/2033 0:00	3629	155.8741
7/24/2033 0:00	3492	155.4818	9/8/2033 0:00	3538	155.6152	10/24/2033 0:00	3584	155.7469	12/9/2033 0:00	3630	155.8769
7/25/2033 0:00	3493	155.4847	9/9/2033 0:00	3539	155.6181	10/25/2033 0:00	3585	155.7497	12/10/2033 0:00	3631	155.8797
7/26/2033 0:00	3494	155.4876	9/10/2033 0:00	3540	155.621	10/26/2033 0:00	3586	155.7526	12/11/2033 0:00	3632	155.8825
7/27/2033 0:00	3495	155.4906	9/11/2033 0:00	3541	155.6239	10/27/2033 0:00	3587	155.7554	12/12/2033 0:00	3633	155.8853
7/28/2033 0:00	3496	155.4935	9/12/2033 0:00	3542	155.6267	10/28/2033 0:00	3588	155.7583	12/13/2033 0:00	3634	155.8881
7/29/2033 0:00	3497	155.4964	9/13/2033 0:00	3543	155.6296	10/29/2033 0:00	3589	155.7611	12/14/2033 0:00	3635	155.8909
7/30/2033 0:00	3498	155.4993	9/14/2033 0:00	3544	155.6325	10/30/2033 0:00	3590	155.764	12/15/2033 0:00	3636	155.8937
7/31/2033 0:00	3499	155.5022	9/15/2033 0:00	3545	155.6354	10/31/2033 0:00	3591	155.7668	12/16/2033 0:00	3637	155.8966
8/1/2033 0:00	3500	155.5051	9/16/2033 0:00	3546	155.6382	11/1/2033 0:00	3592	155.7696	12/17/2033 0:00	3638	155.8994
8/2/2033 0:00	3501	155.508	9/17/2033 0:00	3547	155.6411	11/2/2033 0:00	3593	155.7725	12/18/2033 0:00	3639	155.9022
8/3/2033 0:00	3502	155.511	9/18/2033 0:00	3548	155.644	11/3/2033 0:00	3594	155.7753	12/19/2033 0:00	3640	155.905
8/4/2033 0:00	3503	155.5139	9/19/2033 0:00	3549	155.6469	11/4/2033 0:00	3595	155.7781	12/20/2033 0:00	3641	155.9078
8/5/2033 0:00	3504	155.5168	9/20/2033 0:00	3550	155.6497	11/5/2033 0:00	3596	155.781	12/21/2033 0:00	3642	155.9106
8/6/2033 0:00	3505	155.5197	9/21/2033 0:00	3551	155.6526	11/6/2033 0:00	3597	155.7838	12/22/2033 0:00	3643	155.9134
8/7/2033 0:00	3506	155.5226	9/22/2033 0:00	3552	155.6555	11/7/2033 0:00	3598	155.7866	12/23/2033 0:00	3644	155.9162
8/8/2033 0:00	3507	155.5255	9/23/2033 0:00	3553	155.6583	11/8/2033 0:00	3599	155.7895	12/24/2033 0:00	3645	155.919
8/9/2033 0:00	3508	155.5284	9/24/2033 0:00	3554	155.6612	11/9/2033 0:00	3600	155.7923	12/25/2033 0:00	3646	155.9217
8/10/2033 0:00	3509	155.5313	9/25/2033 0:00	3555	155.6641	11/10/2033 0:00	3601	155.7951	12/26/2033 0:00	3647	155.9245
8/11/2033 0:00	3510	155.5342	9/26/2033 0:00	3556	155.6669	11/11/2033 0:00	3602	155.798	12/27/2033 0:00	3648	155.9273
8/12/2033 0:00	3511	155.5371	9/27/2033 0:00	3557	155.6698	11/12/2033 0:00	3603	155.8008	12/28/2033 0:00	3649	155.9301
8/13/2033 0:00	3512	155.54	9/28/2033 0:00	3558	155.6727	11/13/2033 0:00	3604	155.8036	12/29/2033 0:00	3650	155.9329
8/14/2033 0:00	3513	155.5429	9/29/2033 0:00	3559	155.6755	11/14/2033 0:00	3605	155.8065	12/30/2033 0:00	3651	155.9357
8/15/2033 0:00	3514	155.5458	9/30/2033 0:00	3560	155.6784	11/15/2033 0:00	3606	155.8093	12/31/2033 0:00	3652	155.9385
8/16/2033 0:00	3515	155.5487	10/1/2033 0:00	3561	155.6813	11/16/2033 0:00	3607	155.8121	1/1/2034 0:00	3653	155.9413
8/17/2033 0:00	3516	155.5516	10/2/2033 0:00	3562	155.6841	11/17/2033 0:00	3608	155.8149	1/2/2034 0:00	3654	155.9441
8/18/2033 0:00	3517	155.5545	10/3/2033 0:00	3563	155.687	11/18/2033 0:00	3609	155.8178	1/3/2034 0:00	3655	155.9469
8/19/2033 0:00	3518	155.5574	10/4/2033 0:00	3564	155.6899	11/19/2033 0:00	3610	155.8206	1/4/2034 0:00	3656	155.9497
8/20/2033 0:00	3519	155.5603	10/5/2033 0:00	3565	155.6927	11/20/2033 0:00	3611	155.8234	1/5/2034 0:00	3657	155.9525
8/21/2033 0:00	3520	155.5632	10/6/2033 0:00	3566	155.6956	11/21/2033 0:00	3612	155.8262	1/6/2034 0:00	3658	155.9552
8/22/2033 0:00	3521	155.5661	10/7/2033 0:00	3567	155.6984	11/22/2033 0:00	3613	155.8291	1/7/2034 0:00	3659	155.958
8/23/2033 0:00	3522	155.569	10/8/2033 0:00	3568	155.7013	11/23/2033 0:00	3614	155.8319	1/8/2034 0:00	3660	155.9608
8/24/2033 0:00	3523	155.5719	10/9/2033 0:00	3569	155.7041	11/24/2033 0:00	3615	155.8347	1/9/2034 0:00	3661	155.9636
8/25/2033 0:00	3524	155.5748	10/10/2033 0:00	3570	155.707	11/25/2033 0:00	3616	155.8375	1/10/2034 0:00	3662	155.9664
8/26/2033 0:00	3525	155.5777	10/11/2033 0:00	3571	155.7099	11/26/2033 0:00	3617	155.8403	1/11/2034 0:00	3663	155.9692
8/27/2033 0:00	3526	155.5806	10/12/2033 0:00	3572	155.7127	11/27/2033 0:00	3618	155.8432	1/12/2034 0:00	3664	155.972
8/28/2033 0:00	3527	155.5835	10/13/2033 0:00	3573	155.7156	11/28/2033 0:00	3619	155.846	1/13/2034 0:00	3665	155.9747
8/29/2033 0:00	3528	155.5864	10/14/2033 0:00	3574	155.7184	11/29/2033 0:00	3620	155.8488	1/14/2034 0:00	3666	155.9775
8/30/2033 0:00	3529	155.5892	10/15/2033 0:00	3575	155.7213	11/30/2033 0:00	3621	155.8516	1/15/2034 0:00	3667	155.9803

1/16/2034 0:00	3668	155.9831	3/3/2034 0:00	3714	156.1101	4/18/2034 0:00	3760	156.2356	6/3/2034 0:00	3806	156.3596
1/17/2034 0:00	3669	155.9859	3/4/2034 0:00	3715	156.1129	4/19/2034 0:00	3761	156.2383	6/4/2034 0:00	3807	156.3623
1/18/2034 0:00	3670	155.9886	3/5/2034 0:00	3716	156.1156	4/20/2034 0:00	3762	156.241	6/5/2034 0:00	3808	156.365
1/19/2034 0:00	3671	155.9914	3/6/2034 0:00	3717	156.1184	4/21/2034 0:00	3763	156.2438	6/6/2034 0:00	3809	156.3676
1/20/2034 0:00	3672	155.9942	3/7/2034 0:00	3718	156.1211	4/22/2034 0:00	3764	156.2465	6/7/2034 0:00	3810	156.3703
1/21/2034 0:00	3673	155.997	3/8/2034 0:00	3719	156.1238	4/23/2034 0:00	3765	156.2492	6/8/2034 0:00	3811	156.373
1/22/2034 0:00	3674	155.9997	3/9/2034 0:00	3720	156.1266	4/24/2034 0:00	3766	156.2519	6/9/2034 0:00	3812	156.3757
1/23/2034 0:00	3675	156.0025	3/10/2034 0:00	3721	156.1293	4/25/2034 0:00	3767	156.2546	6/10/2034 0:00	3813	156.3783
1/24/2034 0:00	3676	156.0053	3/11/2034 0:00	3722	156.1321	4/26/2034 0:00	3768	156.2573	6/11/2034 0:00	3814	156.381
1/25/2034 0:00	3677	156.0081	3/12/2034 0:00	3723	156.1348	4/27/2034 0:00	3769	156.26	6/12/2034 0:00	3815	156.3837
1/26/2034 0:00	3678	156.0108	3/13/2034 0:00	3724	156.1375	4/28/2034 0:00	3770	156.2627	6/13/2034 0:00	3816	156.3863
1/27/2034 0:00	3679	156.0136	3/14/2034 0:00	3725	156.1403	4/29/2034 0:00	3771	156.2654	6/14/2034 0:00	3817	156.389
1/28/2034 0:00	3680	156.0164	3/15/2034 0:00	3726	156.143	4/30/2034 0:00	3772	156.2681	6/15/2034 0:00	3818	156.3917
1/29/2034 0:00	3681	156.0191	3/16/2034 0:00	3727	156.1458	5/1/2034 0:00	3773	156.2708	6/16/2034 0:00	3819	156.3944
1/30/2034 0:00	3682	156.0219	3/17/2034 0:00	3728	156.1485	5/2/2034 0:00	3774	156.2735	6/17/2034 0:00	3820	156.397
1/31/2034 0:00	3683	156.0247	3/18/2034 0:00	3729	156.1512	5/3/2034 0:00	3775	156.2762	6/18/2034 0:00	3821	156.3997
2/1/2034 0:00	3684	156.0275	3/19/2034 0:00	3730	156.154	5/4/2034 0:00	3776	156.2789	6/19/2034 0:00	3822	156.4024
2/2/2034 0:00	3685	156.0302	3/20/2034 0:00	3731	156.1567	5/5/2034 0:00	3777	156.2816	6/20/2034 0:00	3823	156.405
2/3/2034 0:00	3686	156.033	3/21/2034 0:00	3732	156.1594	5/6/2034 0:00	3778	156.2843	6/21/2034 0:00	3824	156.4077
2/4/2034 0:00	3687	156.0357	3/22/2034 0:00	3733	156.1622	5/7/2034 0:00	3779	156.287	6/22/2034 0:00	3825	156.4104
2/5/2034 0:00	3688	156.0385	3/23/2034 0:00	3734	156.1649	5/8/2034 0:00	3780	156.2897	6/23/2034 0:00	3826	156.413
2/6/2034 0:00	3689	156.0413	3/24/2034 0:00	3735	156.1676	5/9/2034 0:00	3781	156.2924	6/24/2034 0:00	3827	156.4157
2/7/2034 0:00	3690	156.044	3/25/2034 0:00	3736	156.1703	5/10/2034 0:00	3782	156.2951	6/25/2034 0:00	3828	156.4184
2/8/2034 0:00	3691	156.0468	3/26/2034 0:00	3737	156.1731	5/11/2034 0:00	3783	156.2978	6/26/2034 0:00	3829	156.421
2/9/2034 0:00	3692	156.0496	3/27/2034 0:00	3738	156.1758	5/12/2034 0:00	3784	156.3005	6/27/2034 0:00	3830	156.4237
2/10/2034 0:00	3693	156.0523	3/28/2034 0:00	3739	156.1785	5/13/2034 0:00	3785	156.3032	6/28/2034 0:00	3831	156.4263
2/11/2034 0:00	3694	156.0551	3/29/2034 0:00	3740	156.1813	5/14/2034 0:00	3786	156.3059	6/29/2034 0:00	3832	156.429
2/12/2034 0:00	3695	156.0578	3/30/2034 0:00	3741	156.184	5/15/2034 0:00	3787	156.3086	6/30/2034 0:00	3833	156.4317
2/13/2034 0:00	3696	156.0606	3/31/2034 0:00	3742	156.1867	5/16/2034 0:00	3788	156.3113	7/1/2034 0:00	3834	156.4343
2/14/2034 0:00	3697	156.0634	4/1/2034 0:00	3743	156.1894	5/17/2034 0:00	3789	156.314	7/2/2034 0:00	3835	156.437
2/15/2034 0:00	3698	156.0661	4/2/2034 0:00	3744	156.1922	5/18/2034 0:00	3790	156.3166	7/3/2034 0:00	3836	156.4396
2/16/2034 0:00	3699	156.0689	4/3/2034 0:00	3745	156.1949	5/19/2034 0:00	3791	156.3193	7/4/2034 0:00	3837	156.4423
2/17/2034 0:00	3700	156.0716	4/4/2034 0:00	3746	156.1976	5/20/2034 0:00	3792	156.322	7/5/2034 0:00	3838	156.445
2/18/2034 0:00	3701	156.0744	4/5/2034 0:00	3747	156.2003	5/21/2034 0:00	3793	156.3247	7/6/2034 0:00	3839	156.4476
2/19/2034 0:00	3702	156.0771	4/6/2034 0:00	3748	156.203	5/22/2034 0:00	3794	156.3274	7/7/2034 0:00	3840	156.4503
2/20/2034 0:00	3703	156.0799	4/7/2034 0:00	3749	156.2058	5/23/2034 0:00	3795	156.3301	7/8/2034 0:00	3841	156.4529
2/21/2034 0:00	3704	156.0826	4/8/2034 0:00	3750	156.2085	5/24/2034 0:00	3796	156.3328	7/9/2034 0:00	3842	156.4556
2/22/2034 0:00	3705	156.0854	4/9/2034 0:00	3751	156.2112	5/25/2034 0:00	3797	156.3355	7/10/2034 0:00	3843	156.4582
2/23/2034 0:00	3706	156.0882	4/10/2034 0:00	3752	156.2139	5/26/2034 0:00	3798	156.3381	7/11/2034 0:00	3844	156.4609
2/24/2034 0:00	3707	156.0909	4/11/2034 0:00	3753	156.2166	5/27/2034 0:00	3799	156.3408	7/12/2034 0:00	3845	156.4635
2/25/2034 0:00	3708	156.0937	4/12/2034 0:00	3754	156.2193	5/28/2034 0:00	3800	156.3435	7/13/2034 0:00	3846	156.4662
2/26/2034 0:00	3709	156.0964	4/13/2034 0:00	3755	156.2221	5/29/2034 0:00	3801	156.3462	7/14/2034 0:00	3847	156.4688
2/27/2034 0:00	3710	156.0991	4/14/2034 0:00	3756	156.2248	5/30/2034 0:00	3802	156.3489	7/15/2034 0:00	3848	156.4715
2/28/2034 0:00	3711	156.1019	4/15/2034 0:00	3757	156.2275	5/31/2034 0:00	3803	156.3516	7/16/2034 0:00	3849	156.4741
3/1/2034 0:00	3712	156.1046	4/16/2034 0:00	3758	156.2302	6/1/2034 0:00	3804	156.3542	7/17/2034 0:00	3850	156.4768
3/2/2034 0:00	3713	156.1074	4/17/2034 0:00	3759	156.2329	6/2/2034 0:00	3805	156.3569	7/18/2034 0:00	3851	156.4794

7/19/2034 0:00	3852	156.4821	9/3/2034 0:00	3898	156.6031	10/19/2034 0:00	3944	156.7227	12/4/2034 0:00	3990	156.8409
7/20/2034 0:00	3853	156.4847	9/4/2034 0:00	3899	156.6057	10/20/2034 0:00	3945	156.7253	12/5/2034 0:00	3991	156.8435
7/21/2034 0:00	3854	156.4874	9/5/2034 0:00	3900	156.6083	10/21/2034 0:00	3946	156.7279	12/6/2034 0:00	3992	156.846
7/22/2034 0:00	3855	156.49	9/6/2034 0:00	3901	156.6109	10/22/2034 0:00	3947	156.7305	12/7/2034 0:00	3993	156.8486
7/23/2034 0:00	3856	156.4927	9/7/2034 0:00	3902	156.6136	10/23/2034 0:00	3948	156.733	12/8/2034 0:00	3994	156.8512
7/24/2034 0:00	3857	156.4953	9/8/2034 0:00	3903	156.6162	10/24/2034 0:00	3949	156.7356	12/9/2034 0:00	3995	156.8537
7/25/2034 0:00	3858	156.4979	9/9/2034 0:00	3904	156.6188	10/25/2034 0:00	3950	156.7382	12/10/2034 0:00	3996	156.8563
7/26/2034 0:00	3859	156.5006	9/10/2034 0:00	3905	156.6214	10/26/2034 0:00	3951	156.7408	12/11/2034 0:00	3997	156.8588
7/27/2034 0:00	3860	156.5032	9/11/2034 0:00	3906	156.624	10/27/2034 0:00	3952	156.7434	12/12/2034 0:00	3998	156.8614
7/28/2034 0:00	3861	156.5059	9/12/2034 0:00	3907	156.6266	10/28/2034 0:00	3953	156.746	12/13/2034 0:00	3999	156.8639
7/29/2034 0:00	3862	156.5085	9/13/2034 0:00	3908	156.6292	10/29/2034 0:00	3954	156.7485	12/14/2034 0:00	4000	156.8665
7/30/2034 0:00	3863	156.5111	9/14/2034 0:00	3909	156.6318	10/30/2034 0:00	3955	156.7511	12/15/2034 0:00	4001	156.869
7/31/2034 0:00	3864	156.5138	9/15/2034 0:00	3910	156.6344	10/31/2034 0:00	3956	156.7537	12/16/2034 0:00	4002	156.8716
8/1/2034 0:00	3865	156.5164	9/16/2034 0:00	3911	156.637	11/1/2034 0:00	3957	156.7563	12/17/2034 0:00	4003	156.8741
8/2/2034 0:00	3866	156.5191	9/17/2034 0:00	3912	156.6397	11/2/2034 0:00	3958	156.7588	12/18/2034 0:00	4004	156.8766
8/3/2034 0:00	3867	156.5217	9/18/2034 0:00	3913	156.6423	11/3/2034 0:00	3959	156.7614	12/19/2034 0:00	4005	156.8792
8/4/2034 0:00	3868	156.5243	9/19/2034 0:00	3914	156.6449	11/4/2034 0:00	3960	156.764	12/20/2034 0:00	4006	156.8817
8/5/2034 0:00	3869	156.527	9/20/2034 0:00	3915	156.6475	11/5/2034 0:00	3961	156.7666	12/21/2034 0:00	4007	156.8843
8/6/2034 0:00	3870	156.5296	9/21/2034 0:00	3916	156.6501	11/6/2034 0:00	3962	156.7691	12/22/2034 0:00	4008	156.8868
8/7/2034 0:00	3871	156.5322	9/22/2034 0:00	3917	156.6527	11/7/2034 0:00	3963	156.7717	12/23/2034 0:00	4009	156.8894
8/8/2034 0:00	3872	156.5349	9/23/2034 0:00	3918	156.6553	11/8/2034 0:00	3964	156.7743	12/24/2034 0:00	4010	156.8919
8/9/2034 0:00	3873	156.5375	9/24/2034 0:00	3919	156.6579	11/9/2034 0:00	3965	156.7769	12/25/2034 0:00	4011	156.8945
8/10/2034 0:00	3874	156.5401	9/25/2034 0:00	3920	156.6605	11/10/2034 0:00	3966	156.7794	12/26/2034 0:00	4012	156.897
8/11/2034 0:00	3875	156.5428	9/26/2034 0:00	3921	156.6631	11/11/2034 0:00	3967	156.782	12/27/2034 0:00	4013	156.8995
8/12/2034 0:00	3876	156.5454	9/27/2034 0:00	3922	156.6657	11/12/2034 0:00	3968	156.7846	12/28/2034 0:00	4014	156.9021
8/13/2034 0:00	3877	156.548	9/28/2034 0:00	3923	156.6683	11/13/2034 0:00	3969	156.7871	12/29/2034 0:00	4015	156.9046
8/14/2034 0:00	3878	156.5507	9/29/2034 0:00	3924	156.6709	11/14/2034 0:00	3970	156.7897	12/30/2034 0:00	4016	156.9072
8/15/2034 0:00	3879	156.5533	9/30/2034 0:00	3925	156.6735	11/15/2034 0:00	3971	156.7923	12/31/2034 0:00	4017	156.9097
8/16/2034 0:00	3880	156.5559	10/1/2034 0:00	3926	156.6761	11/16/2034 0:00	3972	156.7948	1/1/2035 0:00	4018	156.9122
8/17/2034 0:00	3881	156.5585	10/2/2034 0:00	3927	156.6787	11/17/2034 0:00	3973	156.7974	1/2/2035 0:00	4019	156.9148
8/18/2034 0:00	3882	156.5612	10/3/2034 0:00	3928	156.6813	11/18/2034 0:00	3974	156.8	1/3/2035 0:00	4020	156.9173
8/19/2034 0:00	3883	156.5638	10/4/2034 0:00	3929	156.6839	11/19/2034 0:00	3975	156.8025	1/4/2035 0:00	4021	156.9198
8/20/2034 0:00	3884	156.5664	10/5/2034 0:00	3930	156.6865	11/20/2034 0:00	3976	156.8051	1/5/2035 0:00	4022	156.9224
8/21/2034 0:00	3885	156.569	10/6/2034 0:00	3931	156.6891	11/21/2034 0:00	3977	156.8077	1/6/2035 0:00	4023	156.9249
8/22/2034 0:00	3886	156.5717	10/7/2034 0:00	3932	156.6916	11/22/2034 0:00	3978	156.8102	1/7/2035 0:00	4024	156.9274
8/23/2034 0:00	3887	156.5743	10/8/2034 0:00	3933	156.6942	11/23/2034 0:00	3979	156.8128	1/8/2035 0:00	4025	156.93
8/24/2034 0:00	3888	156.5769	10/9/2034 0:00	3934	156.6968	11/24/2034 0:00	3980	156.8154	1/9/2035 0:00	4026	156.9325
8/25/2034 0:00	3889	156.5795	10/10/2034 0:00	3935	156.6994	11/25/2034 0:00	3981	156.8179	1/10/2035 0:00	4027	156.935
8/26/2034 0:00	3890	156.5822	10/11/2034 0:00	3936	156.702	11/26/2034 0:00	3982	156.8205	1/11/2035 0:00	4028	156.9376
8/27/2034 0:00	3891	156.5848	10/12/2034 0:00	3937	156.7046	11/27/2034 0:00	3983	156.823	1/12/2035 0:00	4029	156.9401
8/28/2034 0:00	3892	156.5874	10/13/2034 0:00	3938	156.7072	11/28/2034 0:00	3984	156.8256	1/13/2035 0:00	4030	156.9426
8/29/2034 0:00	3893	156.59	10/14/2034 0:00	3939	156.7098	11/29/2034 0:00	3985	156.8282	1/14/2035 0:00	4031	156.9452
8/30/2034 0:00	3894	156.5926	10/15/2034 0:00	3940	156.7124	11/30/2034 0:00	3986	156.8307	1/15/2035 0:00	4032	156.9477
8/31/2034 0:00	3895	156.5953	10/16/2034 0:00	3941	156.715	12/1/2034 0:00	3987	156.8333	1/16/2035 0:00	4033	156.9502
9/1/2034 0:00	3896	156.5979	10/17/2034 0:00	3942	156.7175	12/2/2034 0:00	3988	156.8358	1/17/2035 0:00	4034	156.9528
9/2/2034 0:00	3897	156.6005	10/18/2034 0:00	3943	156.7201	12/3/2034 0:00	3989	156.8384	1/18/2035 0:00	4035	156.9553

1/19/2035 0:00	4036	156.9578	3/6/2035 0:00	4082	157.0734	4/21/2035 0:00	4128	157.1876	6/6/2035 0:00	4174	157.3006
1/20/2035 0:00	4037	156.9603	3/7/2035 0:00	4083	157.0758	4/22/2035 0:00	4129	157.1901	6/7/2035 0:00	4175	157.303
1/21/2035 0:00	4038	156.9629	3/8/2035 0:00	4084	157.0783	4/23/2035 0:00	4130	157.1925	6/8/2035 0:00	4176	157.3055
1/22/2035 0:00	4039	156.9654	3/9/2035 0:00	4085	157.0808	4/24/2035 0:00	4131	157.195	6/9/2035 0:00	4177	157.3079
1/23/2035 0:00	4040	156.9679	3/10/2035 0:00	4086	157.0833	4/25/2035 0:00	4132	157.1975	6/10/2035 0:00	4178	157.3104
1/24/2035 0:00	4041	156.9704	3/11/2035 0:00	4087	157.0858	4/26/2035 0:00	4133	157.1999	6/11/2035 0:00	4179	157.3128
1/25/2035 0:00	4042	156.973	3/12/2035 0:00	4088	157.0883	4/27/2035 0:00	4134	157.2024	6/12/2035 0:00	4180	157.3152
1/26/2035 0:00	4043	156.9755	3/13/2035 0:00	4089	157.0908	4/28/2035 0:00	4135	157.2049	6/13/2035 0:00	4181	157.3177
1/27/2035 0:00	4044	156.978	3/14/2035 0:00	4090	157.0933	4/29/2035 0:00	4136	157.2073	6/14/2035 0:00	4182	157.3201
1/28/2035 0:00	4045	156.9805	3/15/2035 0:00	4091	157.0958	4/30/2035 0:00	4137	157.2098	6/15/2035 0:00	4183	157.3226
1/29/2035 0:00	4046	156.983	3/16/2035 0:00	4092	157.0983	5/1/2035 0:00	4138	157.2123	6/16/2035 0:00	4184	157.325
1/30/2035 0:00	4047	156.9856	3/17/2035 0:00	4093	157.1008	5/2/2035 0:00	4139	157.2147	6/17/2035 0:00	4185	157.3274
1/31/2035 0:00	4048	156.9881	3/18/2035 0:00	4094	157.1033	5/3/2035 0:00	4140	157.2172	6/18/2035 0:00	4186	157.3299
2/1/2035 0:00	4049	156.9906	3/19/2035 0:00	4095	157.1058	5/4/2035 0:00	4141	157.2197	6/19/2035 0:00	4187	157.3323
2/2/2035 0:00	4050	156.9931	3/20/2035 0:00	4096	157.1083	5/5/2035 0:00	4142	157.2221	6/20/2035 0:00	4188	157.3347
2/3/2035 0:00	4051	156.9956	3/21/2035 0:00	4097	157.1107	5/6/2035 0:00	4143	157.2246	6/21/2035 0:00	4189	157.3372
2/4/2035 0:00	4052	156.9981	3/22/2035 0:00	4098	157.1132	5/7/2035 0:00	4144	157.227	6/22/2035 0:00	4190	157.3396
2/5/2035 0:00	4053	157.0007	3/23/2035 0:00	4099	157.1157	5/8/2035 0:00	4145	157.2295	6/23/2035 0:00	4191	157.342
2/6/2035 0:00	4054	157.0032	3/24/2035 0:00	4100	157.1182	5/9/2035 0:00	4146	157.232	6/24/2035 0:00	4192	157.3445
2/7/2035 0:00	4055	157.0057	3/25/2035 0:00	4101	157.1207	5/10/2035 0:00	4147	157.2344	6/25/2035 0:00	4193	157.3469
2/8/2035 0:00	4056	157.0082	3/26/2035 0:00	4102	157.1232	5/11/2035 0:00	4148	157.2369	6/26/2035 0:00	4194	157.3493
2/9/2035 0:00	4057	157.0107	3/27/2035 0:00	4103	157.1257	5/12/2035 0:00	4149	157.2393	6/27/2035 0:00	4195	157.3518
2/10/2035 0:00	4058	157.0132	3/28/2035 0:00	4104	157.1282	5/13/2035 0:00	4150	157.2418	6/28/2035 0:00	4196	157.3542
2/11/2035 0:00	4059	157.0157	3/29/2035 0:00	4105	157.1306	5/14/2035 0:00	4151	157.2443	6/29/2035 0:00	4197	157.3566
2/12/2035 0:00	4060	157.0183	3/30/2035 0:00	4106	157.1331	5/15/2035 0:00	4152	157.2467	6/30/2035 0:00	4198	157.359
2/13/2035 0:00	4061	157.0208	3/31/2035 0:00	4107	157.1356	5/16/2035 0:00	4153	157.2492	7/1/2035 0:00	4199	157.3615
2/14/2035 0:00	4062	157.0233	4/1/2035 0:00	4108	157.1381	5/17/2035 0:00	4154	157.2516	7/2/2035 0:00	4200	157.3639
2/15/2035 0:00	4063	157.0258	4/2/2035 0:00	4109	157.1406	5/18/2035 0:00	4155	157.2541	7/3/2035 0:00	4201	157.3663
2/16/2035 0:00	4064	157.0283	4/3/2035 0:00	4110	157.143	5/19/2035 0:00	4156	157.2565	7/4/2035 0:00	4202	157.3688
2/17/2035 0:00	4065	157.0308	4/4/2035 0:00	4111	157.1455	5/20/2035 0:00	4157	157.259	7/5/2035 0:00	4203	157.3712
2/18/2035 0:00	4066	157.0333	4/5/2035 0:00	4112	157.148	5/21/2035 0:00	4158	157.2614	7/6/2035 0:00	4204	157.3736
2/19/2035 0:00	4067	157.0358	4/6/2035 0:00	4113	157.1505	5/22/2035 0:00	4159	157.2639	7/7/2035 0:00	4205	157.376
2/20/2035 0:00	4068	157.0383	4/7/2035 0:00	4114	157.153	5/23/2035 0:00	4160	157.2663	7/8/2035 0:00	4206	157.3785
2/21/2035 0:00	4069	157.0408	4/8/2035 0:00	4115	157.1554	5/24/2035 0:00	4161	157.2688	7/9/2035 0:00	4207	157.3809
2/22/2035 0:00	4070	157.0433	4/9/2035 0:00	4116	157.1579	5/25/2035 0:00	4162	157.2712	7/10/2035 0:00	4208	157.3833
2/23/2035 0:00	4071	157.0458	4/10/2035 0:00	4117	157.1604	5/26/2035 0:00	4163	157.2737	7/11/2035 0:00	4209	157.3857
2/24/2035 0:00	4072	157.0483	4/11/2035 0:00	4118	157.1629	5/27/2035 0:00	4164	157.2761	7/12/2035 0:00	4210	157.3882
2/25/2035 0:00	4073	157.0508	4/12/2035 0:00	4119	157.1654	5/28/2035 0:00	4165	157.2786	7/13/2035 0:00	4211	157.3906
2/26/2035 0:00	4074	157.0533	4/13/2035 0:00	4120	157.1678	5/29/2035 0:00	4166	157.281	7/14/2035 0:00	4212	157.393
2/27/2035 0:00	4075	157.0559	4/14/2035 0:00	4121	157.1703	5/30/2035 0:00	4167	157.2835	7/15/2035 0:00	4213	157.3954
2/28/2035 0:00	4076	157.0584	4/15/2035 0:00	4122	157.1728	5/31/2035 0:00	4168	157.2859	7/16/2035 0:00	4214	157.3978
3/1/2035 0:00	4077	157.0609	4/16/2035 0:00	4123	157.1752	6/1/2035 0:00	4169	157.2884	7/17/2035 0:00	4215	157.4003
3/2/2035 0:00	4078	157.0634	4/17/2035 0:00	4124	157.1777	6/2/2035 0:00	4170	157.2908	7/18/2035 0:00	4216	157.4027
3/3/2035 0:00	4079	157.0659	4/18/2035 0:00	4125	157.1802	6/3/2035 0:00	4171	157.2933	7/19/2035 0:00	4217	157.4051
3/4/2035 0:00	4080	157.0684	4/19/2035 0:00	4126	157.1827	6/4/2035 0:00	4172	157.2957	7/20/2035 0:00	4218	157.4075
3/5/2035 0:00	4081	157.0709	4/20/2035 0:00	4127	157.1851	6/5/2035 0:00	4173	157.2981	7/21/2035 0:00	4219	157.4099

7/22/2035 0:00	4220	157.4123	9/6/2035 0:00	4266	157.5229	10/22/2035 0:00	4312	157.6322	12/7/2035 0:00	4358	157.7404
7/23/2035 0:00	4221	157.4148	9/7/2035 0:00	4267	157.5253	10/23/2035 0:00	4313	157.6346	12/8/2035 0:00	4359	157.7428
7/24/2035 0:00	4222	157.4172	9/8/2035 0:00	4268	157.5277	10/24/2035 0:00	4314	157.637	12/9/2035 0:00	4360	157.7451
7/25/2035 0:00	4223	157.4196	9/9/2035 0:00	4269	157.53	10/25/2035 0:00	4315	157.6393	12/10/2035 0:00	4361	157.7475
7/26/2035 0:00	4224	157.422	9/10/2035 0:00	4270	157.5324	10/26/2035 0:00	4316	157.6417	12/11/2035 0:00	4362	157.7498
7/27/2035 0:00	4225	157.4244	9/11/2035 0:00	4271	157.5348	10/27/2035 0:00	4317	157.6441	12/12/2035 0:00	4363	157.7521
7/28/2035 0:00	4226	157.4268	9/12/2035 0:00	4272	157.5372	10/28/2035 0:00	4318	157.6464	12/13/2035 0:00	4364	157.7545
7/29/2035 0:00	4227	157.4292	9/13/2035 0:00	4273	157.5396	10/29/2035 0:00	4319	157.6488	12/14/2035 0:00	4365	157.7568
7/30/2035 0:00	4228	157.4317	9/14/2035 0:00	4274	157.542	10/30/2035 0:00	4320	157.6511	12/15/2035 0:00	4366	157.7591
7/31/2035 0:00	4229	157.4341	9/15/2035 0:00	4275	157.5444	10/31/2035 0:00	4321	157.6535	12/16/2035 0:00	4367	157.7615
8/1/2035 0:00	4230	157.4365	9/16/2035 0:00	4276	157.5468	11/1/2035 0:00	4322	157.6559	12/17/2035 0:00	4368	157.7638
8/2/2035 0:00	4231	157.4389	9/17/2035 0:00	4277	157.5491	11/2/2035 0:00	4323	157.6582	12/18/2035 0:00	4369	157.7661
8/3/2035 0:00	4232	157.4413	9/18/2035 0:00	4278	157.5515	11/3/2035 0:00	4324	157.6606	12/19/2035 0:00	4370	157.7685
8/4/2035 0:00	4233	157.4437	9/19/2035 0:00	4279	157.5539	11/4/2035 0:00	4325	157.6629	12/20/2035 0:00	4371	157.7708
8/5/2035 0:00	4234	157.4461	9/20/2035 0:00	4280	157.5563	11/5/2035 0:00	4326	157.6653	12/21/2035 0:00	4372	157.7731
8/6/2035 0:00	4235	157.4485	9/21/2035 0:00	4281	157.5587	11/6/2035 0:00	4327	157.6676	12/22/2035 0:00	4373	157.7755
8/7/2035 0:00	4236	157.4509	9/22/2035 0:00	4282	157.5611	11/7/2035 0:00	4328	157.67	12/23/2035 0:00	4374	157.7778
8/8/2035 0:00	4237	157.4533	9/23/2035 0:00	4283	157.5634	11/8/2035 0:00	4329	157.6724	12/24/2035 0:00	4375	157.7801
8/9/2035 0:00	4238	157.4557	9/24/2035 0:00	4284	157.5658	11/9/2035 0:00	4330	157.6747	12/25/2035 0:00	4376	157.7825
8/10/2035 0:00	4239	157.4581	9/25/2035 0:00	4285	157.5682	11/10/2035 0:00	4331	157.6771	12/26/2035 0:00	4377	157.7848
8/11/2035 0:00	4240	157.4605	9/26/2035 0:00	4286	157.5706	11/11/2035 0:00	4332	157.6794	12/27/2035 0:00	4378	157.7871
8/12/2035 0:00	4241	157.463	9/27/2035 0:00	4287	157.573	11/12/2035 0:00	4333	157.6818	12/28/2035 0:00	4379	157.7894
8/13/2035 0:00	4242	157.4654	9/28/2035 0:00	4288	157.5753	11/13/2035 0:00	4334	157.6841	12/29/2035 0:00	4380	157.7918
8/14/2035 0:00	4243	157.4678	9/29/2035 0:00	4289	157.5777	11/14/2035 0:00	4335	157.6865	12/30/2035 0:00	4381	157.7941
8/15/2035 0:00	4244	157.4702	9/30/2035 0:00	4290	157.5801	11/15/2035 0:00	4336	157.6888	12/31/2035 0:00	4382	157.7964
8/16/2035 0:00	4245	157.4726	10/1/2035 0:00	4291	157.5825	11/16/2035 0:00	4337	157.6912	1/1/2036 0:00	4383	157.7988
8/17/2035 0:00	4246	157.475	10/2/2035 0:00	4292	157.5848	11/17/2035 0:00	4338	157.6935	1/2/2036 0:00	4384	157.8011
8/18/2035 0:00	4247	157.4774	10/3/2035 0:00	4293	157.5872	11/18/2035 0:00	4339	157.6959	1/3/2036 0:00	4385	157.8034
8/19/2035 0:00	4248	157.4798	10/4/2035 0:00	4294	157.5896	11/19/2035 0:00	4340	157.6982	1/4/2036 0:00	4386	157.8057
8/20/2035 0:00	4249	157.4822	10/5/2035 0:00	4295	157.592	11/20/2035 0:00	4341	157.7006	1/5/2036 0:00	4387	157.8081
8/21/2035 0:00	4250	157.4846	10/6/2035 0:00	4296	157.5943	11/21/2035 0:00	4342	157.7029	1/6/2036 0:00	4388	157.8104
8/22/2035 0:00	4251	157.487	10/7/2035 0:00	4297	157.5967	11/22/2035 0:00	4343	157.7053	1/7/2036 0:00	4389	157.8127
8/23/2035 0:00	4252	157.4894	10/8/2035 0:00	4298	157.5991	11/23/2035 0:00	4344	157.7076	1/8/2036 0:00	4390	157.815
8/24/2035 0:00	4253	157.4918	10/9/2035 0:00	4299	157.6015	11/24/2035 0:00	4345	157.71	1/9/2036 0:00	4391	157.8174
8/25/2035 0:00	4254	157.4942	10/10/2035 0:00	4300	157.6038	11/25/2035 0:00	4346	157.7123	1/10/2036 0:00	4392	157.8197
8/26/2035 0:00	4255	157.4966	10/11/2035 0:00	4301	157.6062	11/26/2035 0:00	4347	157.7147	1/11/2036 0:00	4393	157.822
8/27/2035 0:00	4256	157.499	10/12/2035 0:00	4302	157.6086	11/27/2035 0:00	4348	157.717	1/12/2036 0:00	4394	157.8243
8/28/2035 0:00	4257	157.5013	10/13/2035 0:00	4303	157.6109	11/28/2035 0:00	4349	157.7194	1/13/2036 0:00	4395	157.8266
8/29/2035 0:00	4258	157.5037	10/14/2035 0:00	4304	157.6133	11/29/2035 0:00	4350	157.7217	1/14/2036 0:00	4396	157.829
8/30/2035 0:00	4259	157.5061	10/15/2035 0:00	4305	157.6157	11/30/2035 0:00	4351	157.724	1/15/2036 0:00	4397	157.8313
8/31/2035 0:00	4260	157.5085	10/16/2035 0:00	4306	157.618	12/1/2035 0:00	4352	157.7264	1/16/2036 0:00	4398	157.8336
9/1/2035 0:00	4261	157.5109	10/17/2035 0:00	4307	157.6204	12/2/2035 0:00	4353	157.7287	1/17/2036 0:00	4399	157.8359
9/2/2035 0:00	4262	157.5133	10/18/2035 0:00	4308	157.6228	12/3/2035 0:00	4354	157.7311	1/18/2036 0:00	4400	157.8382
9/3/2035 0:00	4263	157.5157	10/19/2035 0:00	4309	157.6251	12/4/2035 0:00	4355	157.7334	1/19/2036 0:00	4401	157.8405
9/4/2035 0:00	4264	157.5181	10/20/2035 0:00	4310	157.6275	12/5/2035 0:00	4356	157.7358	1/20/2036 0:00	4402	157.8429
9/5/2035 0:00	4265	157.5205	10/21/2035 0:00	4311	157.6299	12/6/2035 0:00	4357	157.7381	1/21/2036 0:00	4403	157.8452

1/22/2036 0:00	4404	157.8475	3/8/2036 0:00	4450	157.9534	4/23/2036 0:00	4496	158.0583	6/8/2036 0:00	4542	158.1621
1/23/2036 0:00	4405	157.8498	3/9/2036 0:00	4451	157.9557	4/24/2036 0:00	4497	158.0606	6/9/2036 0:00	4543	158.1643
1/24/2036 0:00	4406	157.8521	3/10/2036 0:00	4452	157.958	4/25/2036 0:00	4498	158.0628	6/10/2036 0:00	4544	158.1666
1/25/2036 0:00	4407	157.8544	3/11/2036 0:00	4453	157.9603	4/26/2036 0:00	4499	158.0651	6/11/2036 0:00	4545	158.1688
1/26/2036 0:00	4408	157.8568	3/12/2036 0:00	4454	157.9626	4/27/2036 0:00	4500	158.0674	6/12/2036 0:00	4546	158.1711
1/27/2036 0:00	4409	157.8591	3/13/2036 0:00	4455	157.9649	4/28/2036 0:00	4501	158.0696	6/13/2036 0:00	4547	158.1733
1/28/2036 0:00	4410	157.8614	3/14/2036 0:00	4456	157.9672	4/29/2036 0:00	4502	158.0719	6/14/2036 0:00	4548	158.1756
1/29/2036 0:00	4411	157.8637	3/15/2036 0:00	4457	157.9695	4/30/2036 0:00	4503	158.0742	6/15/2036 0:00	4549	158.1778
1/30/2036 0:00	4412	157.866	3/16/2036 0:00	4458	157.9718	5/1/2036 0:00	4504	158.0764	6/16/2036 0:00	4550	158.18
1/31/2036 0:00	4413	157.8683	3/17/2036 0:00	4459	157.974	5/2/2036 0:00	4505	158.0787	6/17/2036 0:00	4551	158.1823
2/1/2036 0:00	4414	157.8706	3/18/2036 0:00	4460	157.9763	5/3/2036 0:00	4506	158.081	6/18/2036 0:00	4552	158.1845
2/2/2036 0:00	4415	157.8729	3/19/2036 0:00	4461	157.9786	5/4/2036 0:00	4507	158.0832	6/19/2036 0:00	4553	158.1868
2/3/2036 0:00	4416	157.8752	3/20/2036 0:00	4462	157.9809	5/5/2036 0:00	4508	158.0855	6/20/2036 0:00	4554	158.189
2/4/2036 0:00	4417	157.8775	3/21/2036 0:00	4463	157.9832	5/6/2036 0:00	4509	158.0877	6/21/2036 0:00	4555	158.1912
2/5/2036 0:00	4418	157.8799	3/22/2036 0:00	4464	157.9855	5/7/2036 0:00	4510	158.09	6/22/2036 0:00	4556	158.1935
2/6/2036 0:00	4419	157.8822	3/23/2036 0:00	4465	157.9878	5/8/2036 0:00	4511	158.0923	6/23/2036 0:00	4557	158.1957
2/7/2036 0:00	4420	157.8845	3/24/2036 0:00	4466	157.99	5/9/2036 0:00	4512	158.0945	6/24/2036 0:00	4558	158.198
2/8/2036 0:00	4421	157.8868	3/25/2036 0:00	4467	157.9923	5/10/2036 0:00	4513	158.0968	6/25/2036 0:00	4559	158.2002
2/9/2036 0:00	4422	157.8891	3/26/2036 0:00	4468	157.9946	5/11/2036 0:00	4514	158.099	6/26/2036 0:00	4560	158.2024
2/10/2036 0:00	4423	157.8914	3/27/2036 0:00	4469	157.9969	5/12/2036 0:00	4515	158.1013	6/27/2036 0:00	4561	158.2047
2/11/2036 0:00	4424	157.8937	3/28/2036 0:00	4470	157.9992	5/13/2036 0:00	4516	158.1036	6/28/2036 0:00	4562	158.2069
2/12/2036 0:00	4425	157.896	3/29/2036 0:00	4471	158.0014	5/14/2036 0:00	4517	158.1058	6/29/2036 0:00	4563	158.2091
2/13/2036 0:00	4426	157.8983	3/30/2036 0:00	4472	158.0037	5/15/2036 0:00	4518	158.1081	6/30/2036 0:00	4564	158.2114
2/14/2036 0:00	4427	157.9006	3/31/2036 0:00	4473	158.006	5/16/2036 0:00	4519	158.1103	7/1/2036 0:00	4565	158.2136
2/15/2036 0:00	4428	157.9029	4/1/2036 0:00	4474	158.0083	5/17/2036 0:00	4520	158.1126	7/2/2036 0:00	4566	158.2158
2/16/2036 0:00	4429	157.9052	4/2/2036 0:00	4475	158.0106	5/18/2036 0:00	4521	158.1148	7/3/2036 0:00	4567	158.2181
2/17/2036 0:00	4430	157.9075	4/3/2036 0:00	4476	158.0128	5/19/2036 0:00	4522	158.1171	7/4/2036 0:00	4568	158.2203
2/18/2036 0:00	4431	157.9098	4/4/2036 0:00	4477	158.0151	5/20/2036 0:00	4523	158.1194	7/5/2036 0:00	4569	158.2225
2/19/2036 0:00	4432	157.9121	4/5/2036 0:00	4478	158.0174	5/21/2036 0:00	4524	158.1216	7/6/2036 0:00	4570	158.2248
2/20/2036 0:00	4433	157.9144	4/6/2036 0:00	4479	158.0197	5/22/2036 0:00	4525	158.1239	7/7/2036 0:00	4571	158.227
2/21/2036 0:00	4434	157.9167	4/7/2036 0:00	4480	158.022	5/23/2036 0:00	4526	158.1261	7/8/2036 0:00	4572	158.2292
2/22/2036 0:00	4435	157.919	4/8/2036 0:00	4481	158.0242	5/24/2036 0:00	4527	158.1284	7/9/2036 0:00	4573	158.2315
2/23/2036 0:00	4436	157.9213	4/9/2036 0:00	4482	158.0265	5/25/2036 0:00	4528	158.1306	7/10/2036 0:00	4574	158.2337
2/24/2036 0:00	4437	157.9236	4/10/2036 0:00	4483	158.0288	5/26/2036 0:00	4529	158.1329	7/11/2036 0:00	4575	158.2359
2/25/2036 0:00	4438	157.9259	4/11/2036 0:00	4484	158.0311	5/27/2036 0:00	4530	158.1351	7/12/2036 0:00	4576	158.2381
2/26/2036 0:00	4439	157.9282	4/12/2036 0:00	4485	158.0333	5/28/2036 0:00	4531	158.1374	7/13/2036 0:00	4577	158.2404
2/27/2036 0:00	4440	157.9305	4/13/2036 0:00	4486	158.0356	5/29/2036 0:00	4532	158.1396	7/14/2036 0:00	4578	158.2426
2/28/2036 0:00	4441	157.9328	4/14/2036 0:00	4487	158.0379	5/30/2036 0:00	4533	158.1419	7/15/2036 0:00	4579	158.2448
2/29/2036 0:00	4442	157.9351	4/15/2036 0:00	4488	158.0401	5/31/2036 0:00	4534	158.1441	7/16/2036 0:00	4580	158.2471
3/1/2036 0:00	4443	157.9374	4/16/2036 0:00	4489	158.0424	6/1/2036 0:00	4535	158.1464	7/17/2036 0:00	4581	158.2493
3/2/2036 0:00	4444	157.9397	4/17/2036 0:00	4490	158.0447	6/2/2036 0:00	4536	158.1486	7/18/2036 0:00	4582	158.2515
3/3/2036 0:00	4445	157.942	4/18/2036 0:00	4491	158.047	6/3/2036 0:00	4537	158.1509	7/19/2036 0:00	4583	158.2537
3/4/2036 0:00	4446	157.9443	4/19/2036 0:00	4492	158.0492	6/4/2036 0:00	4538	158.1531	7/20/2036 0:00	4584	158.256
3/5/2036 0:00	4447	157.9466	4/20/2036 0:00	4493	158.0515	6/5/2036 0:00	4539	158.1554	7/21/2036 0:00	4585	158.2582
3/6/2036 0:00	4448	157.9489	4/21/2036 0:00	4494	158.0538	6/6/2036 0:00	4540	158.1576	7/22/2036 0:00	4586	158.2604
3/7/2036 0:00	4449	157.9512	4/22/2036 0:00	4495	158.056	6/7/2036 0:00	4541	158.1599	7/23/2036 0:00	4587	158.2626

7/24/2036 0:00	4588	158.2648	9/8/2036 0:00	4634	158.3666	10/24/2036 0:00	4680	158.4673	12/9/2036 0:00	4726	158.567
7/25/2036 0:00	4589	158.2671	9/9/2036 0:00	4635	158.3688	10/25/2036 0:00	4681	158.4695	12/10/2036 0:00	4727	158.5692
7/26/2036 0:00	4590	158.2693	9/10/2036 0:00	4636	158.371	10/26/2036 0:00	4682	158.4717	12/11/2036 0:00	4728	158.5713
7/27/2036 0:00	4591	158.2715	9/11/2036 0:00	4637	158.3732	10/27/2036 0:00	4683	158.4738	12/12/2036 0:00	4729	158.5735
7/28/2036 0:00	4592	158.2737	9/12/2036 0:00	4638	158.3754	10/28/2036 0:00	4684	158.476	12/13/2036 0:00	4730	158.5757
7/29/2036 0:00	4593	158.276	9/13/2036 0:00	4639	158.3776	10/29/2036 0:00	4685	158.4782	12/14/2036 0:00	4731	158.5778
7/30/2036 0:00	4594	158.2782	9/14/2036 0:00	4640	158.3798	10/30/2036 0:00	4686	158.4804	12/15/2036 0:00	4732	158.58
7/31/2036 0:00	4595	158.2804	9/15/2036 0:00	4641	158.382	10/31/2036 0:00	4687	158.4825	12/16/2036 0:00	4733	158.5821
8/1/2036 0:00	4596	158.2826	9/16/2036 0:00	4642	158.3842	11/1/2036 0:00	4688	158.4847	12/17/2036 0:00	4734	158.5843
8/2/2036 0:00	4597	158.2848	9/17/2036 0:00	4643	158.3864	11/2/2036 0:00	4689	158.4869	12/18/2036 0:00	4735	158.5864
8/3/2036 0:00	4598	158.287	9/18/2036 0:00	4644	158.3886	11/3/2036 0:00	4690	158.4891	12/19/2036 0:00	4736	158.5886
8/4/2036 0:00	4599	158.2893	9/19/2036 0:00	4645	158.3907	11/4/2036 0:00	4691	158.4912	12/20/2036 0:00	4737	158.5907
8/5/2036 0:00	4600	158.2915	9/20/2036 0:00	4646	158.3929	11/5/2036 0:00	4692	158.4934	12/21/2036 0:00	4738	158.5929
8/6/2036 0:00	4601	158.2937	9/21/2036 0:00	4647	158.3951	11/6/2036 0:00	4693	158.4956	12/22/2036 0:00	4739	158.595
8/7/2036 0:00	4602	158.2959	9/22/2036 0:00	4648	158.3973	11/7/2036 0:00	4694	158.4978	12/23/2036 0:00	4740	158.5972
8/8/2036 0:00	4603	158.2981	9/23/2036 0:00	4649	158.3995	11/8/2036 0:00	4695	158.4999	12/24/2036 0:00	4741	158.5993
8/9/2036 0:00	4604	158.3003	9/24/2036 0:00	4650	158.4017	11/9/2036 0:00	4696	158.5021	12/25/2036 0:00	4742	158.6015
8/10/2036 0:00	4605	158.3026	9/25/2036 0:00	4651	158.4039	11/10/2036 0:00	4697	158.5043	12/26/2036 0:00	4743	158.6036
8/11/2036 0:00	4606	158.3048	9/26/2036 0:00	4652	158.4061	11/11/2036 0:00	4698	158.5064	12/27/2036 0:00	4744	158.6058
8/12/2036 0:00	4607	158.307	9/27/2036 0:00	4653	158.4083	11/12/2036 0:00	4699	158.5086	12/28/2036 0:00	4745	158.6079
8/13/2036 0:00	4608	158.3092	9/28/2036 0:00	4654	158.4105	11/13/2036 0:00	4700	158.5108	12/29/2036 0:00	4746	158.6101
8/14/2036 0:00	4609	158.3114	9/29/2036 0:00	4655	158.4127	11/14/2036 0:00	4701	158.5129	12/30/2036 0:00	4747	158.6122
8/15/2036 0:00	4610	158.3136	9/30/2036 0:00	4656	158.4149	11/15/2036 0:00	4702	158.5151	12/31/2036 0:00	4748	158.6144
8/16/2036 0:00	4611	158.3158	10/1/2036 0:00	4657	158.4171	11/16/2036 0:00	4703	158.5173	1/1/2037 0:00	4749	158.6165
8/17/2036 0:00	4612	158.318	10/2/2036 0:00	4658	158.4192	11/17/2036 0:00	4704	158.5195	1/2/2037 0:00	4750	158.6187
8/18/2036 0:00	4613	158.3203	10/3/2036 0:00	4659	158.4214	11/18/2036 0:00	4705	158.5216	1/3/2037 0:00	4751	158.6208
8/19/2036 0:00	4614	158.3225	10/4/2036 0:00	4660	158.4236	11/19/2036 0:00	4706	158.5238	1/4/2037 0:00	4752	158.623
8/20/2036 0:00	4615	158.3247	10/5/2036 0:00	4661	158.4258	11/20/2036 0:00	4707	158.526	1/5/2037 0:00	4753	158.6251
8/21/2036 0:00	4616	158.3269	10/6/2036 0:00	4662	158.428	11/21/2036 0:00	4708	158.5281	1/6/2037 0:00	4754	158.6273
8/22/2036 0:00	4617	158.3291	10/7/2036 0:00	4663	158.4302	11/22/2036 0:00	4709	158.5303	1/7/2037 0:00	4755	158.6294
8/23/2036 0:00	4618	158.3313	10/8/2036 0:00	4664	158.4324	11/23/2036 0:00	4710	158.5325	1/8/2037 0:00	4756	158.6316
8/24/2036 0:00	4619	158.3335	10/9/2036 0:00	4665	158.4346	11/24/2036 0:00	4711	158.5346	1/9/2037 0:00	4757	158.6337
8/25/2036 0:00	4620	158.3357	10/10/2036 0:00	4666	158.4367	11/25/2036 0:00	4712	158.5368	1/10/2037 0:00	4758	158.6358
8/26/2036 0:00	4621	158.3379	10/11/2036 0:00	4667	158.4389	11/26/2036 0:00	4713	158.5389	1/11/2037 0:00	4759	158.638
8/27/2036 0:00	4622	158.3401	10/12/2036 0:00	4668	158.4411	11/27/2036 0:00	4714	158.5411	1/12/2037 0:00	4760	158.6401
8/28/2036 0:00	4623	158.3423	10/13/2036 0:00	4669	158.4433	11/28/2036 0:00	4715	158.5433	1/13/2037 0:00	4761	158.6423
8/29/2036 0:00	4624	158.3445	10/14/2036 0:00	4670	158.4455	11/29/2036 0:00	4716	158.5454	1/14/2037 0:00	4762	158.6444
8/30/2036 0:00	4625	158.3468	10/15/2036 0:00	4671	158.4477	11/30/2036 0:00	4717	158.5476	1/15/2037 0:00	4763	158.6466
8/31/2036 0:00	4626	158.349	10/16/2036 0:00	4672	158.4498	12/1/2036 0:00	4718	158.5498	1/16/2037 0:00	4764	158.6487
9/1/2036 0:00	4627	158.3512	10/17/2036 0:00	4673	158.452	12/2/2036 0:00	4719	158.5519	1/17/2037 0:00	4765	158.6508
9/2/2036 0:00	4628	158.3534	10/18/2036 0:00	4674	158.4542	12/3/2036 0:00	4720	158.5541	1/18/2037 0:00	4766	158.653
9/3/2036 0:00	4629	158.3556	10/19/2036 0:00	4675	158.4564	12/4/2036 0:00	4721	158.5562	1/19/2037 0:00	4767	158.6551
9/4/2036 0:00	4630	158.3578	10/20/2036 0:00	4676	158.4586	12/5/2036 0:00	4722	158.5584	1/20/2037 0:00	4768	158.6573
9/5/2036 0:00	4631	158.36	10/21/2036 0:00	4677	158.4608	12/6/2036 0:00	4723	158.5606	1/21/2037 0:00	4769	158.6594
9/6/2036 0:00	4632	158.3622	10/22/2036 0:00	4678	158.4629	12/7/2036 0:00	4724	158.5627	1/22/2037 0:00	4770	158.6615
9/7/2036 0:00	4633	158.3644	10/23/2036 0:00	4679	158.4651	12/8/2036 0:00	4725	158.5649	1/23/2037 0:00	4771	158.6637

1/24/2037 0:00	4772	158.6658	3/11/2037 0:00	4818	158.7636	4/26/2037 0:00	4864	158.8605	6/11/2037 0:00	4910	158.9565
1/25/2037 0:00	4773	158.6679	3/12/2037 0:00	4819	158.7657	4/27/2037 0:00	4865	158.8626	6/12/2037 0:00	4911	158.9586
1/26/2037 0:00	4774	158.6701	3/13/2037 0:00	4820	158.7679	4/28/2037 0:00	4866	158.8647	6/13/2037 0:00	4912	158.9607
1/27/2037 0:00	4775	158.6722	3/14/2037 0:00	4821	158.77	4/29/2037 0:00	4867	158.8668	6/14/2037 0:00	4913	158.9627
1/28/2037 0:00	4776	158.6743	3/15/2037 0:00	4822	158.7721	4/30/2037 0:00	4868	158.8689	6/15/2037 0:00	4914	158.9648
1/29/2037 0:00	4777	158.6765	3/16/2037 0:00	4823	158.7742	5/1/2037 0:00	4869	158.871	6/16/2037 0:00	4915	158.9669
1/30/2037 0:00	4778	158.6786	3/17/2037 0:00	4824	158.7763	5/2/2037 0:00	4870	158.8731	6/17/2037 0:00	4916	158.969
1/31/2037 0:00	4779	158.6807	3/18/2037 0:00	4825	158.7784	5/3/2037 0:00	4871	158.8752	6/18/2037 0:00	4917	158.971
2/1/2037 0:00	4780	158.6829	3/19/2037 0:00	4826	158.7805	5/4/2037 0:00	4872	158.8773	6/19/2037 0:00	4918	158.9731
2/2/2037 0:00	4781	158.685	3/20/2037 0:00	4827	158.7827	5/5/2037 0:00	4873	158.8794	6/20/2037 0:00	4919	158.9752
2/3/2037 0:00	4782	158.6871	3/21/2037 0:00	4828	158.7848	5/6/2037 0:00	4874	158.8815	6/21/2037 0:00	4920	158.9773
2/4/2037 0:00	4783	158.6893	3/22/2037 0:00	4829	158.7869	5/7/2037 0:00	4875	158.8836	6/22/2037 0:00	4921	158.9793
2/5/2037 0:00	4784	158.6914	3/23/2037 0:00	4830	158.789	5/8/2037 0:00	4876	158.8856	6/23/2037 0:00	4922	158.9814
2/6/2037 0:00	4785	158.6935	3/24/2037 0:00	4831	158.7911	5/9/2037 0:00	4877	158.8877	6/24/2037 0:00	4923	158.9835
2/7/2037 0:00	4786	158.6957	3/25/2037 0:00	4832	158.7932	5/10/2037 0:00	4878	158.8898	6/25/2037 0:00	4924	158.9855
2/8/2037 0:00	4787	158.6978	3/26/2037 0:00	4833	158.7953	5/11/2037 0:00	4879	158.8919	6/26/2037 0:00	4925	158.9876
2/9/2037 0:00	4788	158.6999	3/27/2037 0:00	4834	158.7974	5/12/2037 0:00	4880	158.894	6/27/2037 0:00	4926	158.9897
2/10/2037 0:00	4789	158.7021	3/28/2037 0:00	4835	158.7995	5/13/2037 0:00	4881	158.8961	6/28/2037 0:00	4927	158.9918
2/11/2037 0:00	4790	158.7042	3/29/2037 0:00	4836	158.8017	5/14/2037 0:00	4882	158.8982	6/29/2037 0:00	4928	158.9938
2/12/2037 0:00	4791	158.7063	3/30/2037 0:00	4837	158.8038	5/15/2037 0:00	4883	158.9003	6/30/2037 0:00	4929	158.9959
2/13/2037 0:00	4792	158.7084	3/31/2037 0:00	4838	158.8059	5/16/2037 0:00	4884	158.9024	7/1/2037 0:00	4930	158.998
2/14/2037 0:00	4793	158.7106	4/1/2037 0:00	4839	158.808	5/17/2037 0:00	4885	158.9045	7/2/2037 0:00	4931	159
2/15/2037 0:00	4794	158.7127	4/2/2037 0:00	4840	158.8101	5/18/2037 0:00	4886	158.9065	7/3/2037 0:00	4932	159.0021
2/16/2037 0:00	4795	158.7148	4/3/2037 0:00	4841	158.8122	5/19/2037 0:00	4887	158.9086	7/4/2037 0:00	4933	159.0042
2/17/2037 0:00	4796	158.717	4/4/2037 0:00	4842	158.8143	5/20/2037 0:00	4888	158.9107	7/5/2037 0:00	4934	159.0062
2/18/2037 0:00	4797	158.7191	4/5/2037 0:00	4843	158.8164	5/21/2037 0:00	4889	158.9128	7/6/2037 0:00	4935	159.0083
2/19/2037 0:00	4798	158.7212	4/6/2037 0:00	4844	158.8185	5/22/2037 0:00	4890	158.9149	7/7/2037 0:00	4936	159.0104
2/20/2037 0:00	4799	158.7233	4/7/2037 0:00	4845	158.8206	5/23/2037 0:00	4891	158.917	7/8/2037 0:00	4937	159.0124
2/21/2037 0:00	4800	158.7255	4/8/2037 0:00	4846	158.8227	5/24/2037 0:00	4892	158.9191	7/9/2037 0:00	4938	159.0145
2/22/2037 0:00	4801	158.7276	4/9/2037 0:00	4847	158.8248	5/25/2037 0:00	4893	158.9211	7/10/2037 0:00	4939	159.0166
2/23/2037 0:00	4802	158.7297	4/10/2037 0:00	4848	158.8269	5/26/2037 0:00	4894	158.9232	7/11/2037 0:00	4940	159.0186
2/24/2037 0:00	4803	158.7318	4/11/2037 0:00	4849	158.829	5/27/2037 0:00	4895	158.9253	7/12/2037 0:00	4941	159.0207
2/25/2037 0:00	4804	158.734	4/12/2037 0:00	4850	158.8311	5/28/2037 0:00	4896	158.9274	7/13/2037 0:00	4942	159.0228
2/26/2037 0:00	4805	158.7361	4/13/2037 0:00	4851	158.8332	5/29/2037 0:00	4897	158.9295	7/14/2037 0:00	4943	159.0248
2/27/2037 0:00	4806	158.7382	4/14/2037 0:00	4852	158.8353	5/30/2037 0:00	4898	158.9316	7/15/2037 0:00	4944	159.0269
2/28/2037 0:00	4807	158.7403	4/15/2037 0:00	4853	158.8374	5/31/2037 0:00	4899	158.9336	7/16/2037 0:00	4945	159.0289
3/1/2037 0:00	4808	158.7424	4/16/2037 0:00	4854	158.8395	6/1/2037 0:00	4900	158.9357	7/17/2037 0:00	4946	159.031
3/2/2037 0:00	4809	158.7446	4/17/2037 0:00	4855	158.8416	6/2/2037 0:00	4901	158.9378	7/18/2037 0:00	4947	159.0331
3/3/2037 0:00	4810	158.7467	4/18/2037 0:00	4856	158.8437	6/3/2037 0:00	4902	158.9399	7/19/2037 0:00	4948	159.0351
3/4/2037 0:00	4811	158.7488	4/19/2037 0:00	4857	158.8458	6/4/2037 0:00	4903	158.942	7/20/2037 0:00	4949	159.0372
3/5/2037 0:00	4812	158.7509	4/20/2037 0:00	4858	158.8479	6/5/2037 0:00	4904	158.944	7/21/2037 0:00	4950	159.0392
3/6/2037 0:00	4813	158.753	4/21/2037 0:00	4859	158.85	6/6/2037 0:00	4905	158.9461	7/22/2037 0:00	4951	159.0413
3/7/2037 0:00	4814	158.7552	4/22/2037 0:00	4860	158.8521	6/7/2037 0:00	4906	158.9482	7/23/2037 0:00	4952	159.0434
3/8/2037 0:00	4815	158.7573	4/23/2037 0:00	4861	158.8542	6/8/2037 0:00	4907	158.9503	7/24/2037 0:00	4953	159.0454
3/9/2037 0:00	4816	158.7594	4/24/2037 0:00	4862	158.8563	6/9/2037 0:00	4908	158.9524	7/25/2037 0:00	4954	159.0475
3/10/2037 0:00	4817	158.7615	4/25/2037 0:00	4863	158.8584	6/10/2037 0:00	4909	158.9544	7/26/2037 0:00	4955	159.0495

7/27/2037 0:00	4956	159.0516	9/11/2037 0:00	5002	159.1458	10/27/2037 0:00	5048	159.2392	12/12/2037 0:00	5094	159.3317
7/28/2037 0:00	4957	159.0537	9/12/2037 0:00	5003	159.1478	10/28/2037 0:00	5049	159.2412	12/13/2037 0:00	5095	159.3337
7/29/2037 0:00	4958	159.0557	9/13/2037 0:00	5004	159.1499	10/29/2037 0:00	5050	159.2432	12/14/2037 0:00	5096	159.3357
7/30/2037 0:00	4959	159.0578	9/14/2037 0:00	5005	159.1519	10/30/2037 0:00	5051	159.2452	12/15/2037 0:00	5097	159.3377
7/31/2037 0:00	4960	159.0598	9/15/2037 0:00	5006	159.154	10/31/2037 0:00	5052	159.2472	12/16/2037 0:00	5098	159.3397
8/1/2037 0:00	4961	159.0619	9/16/2037 0:00	5007	159.156	11/1/2037 0:00	5053	159.2493	12/17/2037 0:00	5099	159.3417
8/2/2037 0:00	4962	159.0639	9/17/2037 0:00	5008	159.158	11/2/2037 0:00	5054	159.2513	12/18/2037 0:00	5100	159.3437
8/3/2037 0:00	4963	159.066	9/18/2037 0:00	5009	159.1601	11/3/2037 0:00	5055	159.2533	12/19/2037 0:00	5101	159.3457
8/4/2037 0:00	4964	159.068	9/19/2037 0:00	5010	159.1621	11/4/2037 0:00	5056	159.2553	12/20/2037 0:00	5102	159.3477
8/5/2037 0:00	4965	159.0701	9/20/2037 0:00	5011	159.1641	11/5/2037 0:00	5057	159.2573	12/21/2037 0:00	5103	159.3497
8/6/2037 0:00	4966	159.0722	9/21/2037 0:00	5012	159.1662	11/6/2037 0:00	5058	159.2593	12/22/2037 0:00	5104	159.3517
8/7/2037 0:00	4967	159.0742	9/22/2037 0:00	5013	159.1682	11/7/2037 0:00	5059	159.2614	12/23/2037 0:00	5105	159.3537
8/8/2037 0:00	4968	159.0763	9/23/2037 0:00	5014	159.1702	11/8/2037 0:00	5060	159.2634	12/24/2037 0:00	5106	159.3557
8/9/2037 0:00	4969	159.0783	9/24/2037 0:00	5015	159.1723	11/9/2037 0:00	5061	159.2654	12/25/2037 0:00	5107	159.3577
8/10/2037 0:00	4970	159.0804	9/25/2037 0:00	5016	159.1743	11/10/2037 0:00	5062	159.2674	12/26/2037 0:00	5108	159.3597
8/11/2037 0:00	4971	159.0824	9/26/2037 0:00	5017	159.1763	11/11/2037 0:00	5063	159.2694	12/27/2037 0:00	5109	159.3616
8/12/2037 0:00	4972	159.0845	9/27/2037 0:00	5018	159.1784	11/12/2037 0:00	5064	159.2714	12/28/2037 0:00	5110	159.3636
8/13/2037 0:00	4973	159.0865	9/28/2037 0:00	5019	159.1804	11/13/2037 0:00	5065	159.2734	12/29/2037 0:00	5111	159.3656
8/14/2037 0:00	4974	159.0886	9/29/2037 0:00	5020	159.1824	11/14/2037 0:00	5066	159.2755	12/30/2037 0:00	5112	159.3676
8/15/2037 0:00	4975	159.0906	9/30/2037 0:00	5021	159.1845	11/15/2037 0:00	5067	159.2775	12/31/2037 0:00	5113	159.3696
8/16/2037 0:00	4976	159.0927	10/1/2037 0:00	5022	159.1865	11/16/2037 0:00	5068	159.2795	1/1/2038 0:00	5114	159.3716
8/17/2037 0:00	4977	159.0947	10/2/2037 0:00	5023	159.1885	11/17/2037 0:00	5069	159.2815	1/2/2038 0:00	5115	159.3736
8/18/2037 0:00	4978	159.0968	10/3/2037 0:00	5024	159.1906	11/18/2037 0:00	5070	159.2835	1/3/2038 0:00	5116	159.3756
8/19/2037 0:00	4979	159.0988	10/4/2037 0:00	5025	159.1926	11/19/2037 0:00	5071	159.2855	1/4/2038 0:00	5117	159.3776
8/20/2037 0:00	4980	159.1009	10/5/2037 0:00	5026	159.1946	11/20/2037 0:00	5072	159.2875	1/5/2038 0:00	5118	159.3796
8/21/2037 0:00	4981	159.1029	10/6/2037 0:00	5027	159.1966	11/21/2037 0:00	5073	159.2895	1/6/2038 0:00	5119	159.3816
8/22/2037 0:00	4982	159.105	10/7/2037 0:00	5028	159.1987	11/22/2037 0:00	5074	159.2915	1/7/2038 0:00	5120	159.3836
8/23/2037 0:00	4983	159.107	10/8/2037 0:00	5029	159.2007	11/23/2037 0:00	5075	159.2936	1/8/2038 0:00	5121	159.3856
8/24/2037 0:00	4984	159.109	10/9/2037 0:00	5030	159.2027	11/24/2037 0:00	5076	159.2956	1/9/2038 0:00	5122	159.3876
8/25/2037 0:00	4985	159.1111	10/10/2037 0:00	5031	159.2048	11/25/2037 0:00	5077	159.2976	1/10/2038 0:00	5123	159.3896
8/26/2037 0:00	4986	159.1131	10/11/2037 0:00	5032	159.2068	11/26/2037 0:00	5078	159.2996	1/11/2038 0:00	5124	159.3915
8/27/2037 0:00	4987	159.1152	10/12/2037 0:00	5033	159.2088	11/27/2037 0:00	5079	159.3016	1/12/2038 0:00	5125	159.3935
8/28/2037 0:00	4988	159.1172	10/13/2037 0:00	5034	159.2108	11/28/2037 0:00	5080	159.3036	1/13/2038 0:00	5126	159.3955
8/29/2037 0:00	4989	159.1193	10/14/2037 0:00	5035	159.2129	11/29/2037 0:00	5081	159.3056	1/14/2038 0:00	5127	159.3975
8/30/2037 0:00	4990	159.1213	10/15/2037 0:00	5036	159.2149	11/30/2037 0:00	5082	159.3076	1/15/2038 0:00	5128	159.3995
8/31/2037 0:00	4991	159.1234	10/16/2037 0:00	5037	159.2169	12/1/2037 0:00	5083	159.3096	1/16/2038 0:00	5129	159.4015
9/1/2037 0:00	4992	159.1254	10/17/2037 0:00	5038	159.2189	12/2/2037 0:00	5084	159.3116	1/17/2038 0:00	5130	159.4035
9/2/2037 0:00	4993	159.1274	10/18/2037 0:00	5039	159.221	12/3/2037 0:00	5085	159.3136	1/18/2038 0:00	5131	159.4055
9/3/2037 0:00	4994	159.1295	10/19/2037 0:00	5040	159.223	12/4/2037 0:00	5086	159.3156	1/19/2038 0:00	5132	159.4075
9/4/2037 0:00	4995	159.1315	10/20/2037 0:00	5041	159.225	12/5/2037 0:00	5087	159.3176	1/20/2038 0:00	5133	159.4094
9/5/2037 0:00	4996	159.1336	10/21/2037 0:00	5042	159.227	12/6/2037 0:00	5088	159.3196	1/21/2038 0:00	5134	159.4114
9/6/2037 0:00	4997	159.1356	10/22/2037 0:00	5043	159.2291	12/7/2037 0:00	5089	159.3216	1/22/2038 0:00	5135	159.4134
9/7/2037 0:00	4998	159.1377	10/23/2037 0:00	5044	159.2311	12/8/2037 0:00	5090	159.3237	1/23/2038 0:00	5136	159.4154
9/8/2037 0:00	4999	159.1397	10/24/2037 0:00	5045	159.2331	12/9/2037 0:00	5091	159.3257	1/24/2038 0:00	5137	159.4174
9/9/2037 0:00	5000	159.1417	10/25/2037 0:00	5046	159.2351	12/10/2037 0:00	5092	159.3277	1/25/2038 0:00	5138	159.4194
9/10/2037 0:00	5001	159.1438	10/26/2037 0:00	5047	159.2371	12/11/2037 0:00	5093	159.3297	1/26/2038 0:00	5139	159.4214

1/27/2038 0:00	5140	159.4233	3/14/2038 0:00	5186	159.5142	4/29/2038 0:00	5232	159.6042	6/14/2038 0:00	5278	159.6935
1/28/2038 0:00	5141	159.4253	3/15/2038 0:00	5187	159.5162	4/30/2038 0:00	5233	159.6062	6/15/2038 0:00	5279	159.6954
1/29/2038 0:00	5142	159.4273	3/16/2038 0:00	5188	159.5181	5/1/2038 0:00	5234	159.6081	6/16/2038 0:00	5280	159.6974
1/30/2038 0:00	5143	159.4293	3/17/2038 0:00	5189	159.5201	5/2/2038 0:00	5235	159.6101	6/17/2038 0:00	5281	159.6993
1/31/2038 0:00	5144	159.4313	3/18/2038 0:00	5190	159.5221	5/3/2038 0:00	5236	159.612	6/18/2038 0:00	5282	159.7012
2/1/2038 0:00	5145	159.4333	3/19/2038 0:00	5191	159.524	5/4/2038 0:00	5237	159.614	6/19/2038 0:00	5283	159.7032
2/2/2038 0:00	5146	159.4352	3/20/2038 0:00	5192	159.526	5/5/2038 0:00	5238	159.6159	6/20/2038 0:00	5284	159.7051
2/3/2038 0:00	5147	159.4372	3/21/2038 0:00	5193	159.5279	5/6/2038 0:00	5239	159.6179	6/21/2038 0:00	5285	159.707
2/4/2038 0:00	5148	159.4392	3/22/2038 0:00	5194	159.5299	5/7/2038 0:00	5240	159.6198	6/22/2038 0:00	5286	159.709
2/5/2038 0:00	5149	159.4412	3/23/2038 0:00	5195	159.5319	5/8/2038 0:00	5241	159.6218	6/23/2038 0:00	5287	159.7109
2/6/2038 0:00	5150	159.4432	3/24/2038 0:00	5196	159.5338	5/9/2038 0:00	5242	159.6237	6/24/2038 0:00	5288	159.7128
2/7/2038 0:00	5151	159.4451	3/25/2038 0:00	5197	159.5358	5/10/2038 0:00	5243	159.6257	6/25/2038 0:00	5289	159.7147
2/8/2038 0:00	5152	159.4471	3/26/2038 0:00	5198	159.5378	5/11/2038 0:00	5244	159.6276	6/26/2038 0:00	5290	159.7167
2/9/2038 0:00	5153	159.4491	3/27/2038 0:00	5199	159.5397	5/12/2038 0:00	5245	159.6296	6/27/2038 0:00	5291	159.7186
2/10/2038 0:00	5154	159.4511	3/28/2038 0:00	5200	159.5417	5/13/2038 0:00	5246	159.6315	6/28/2038 0:00	5292	159.7205
2/11/2038 0:00	5155	159.4531	3/29/2038 0:00	5201	159.5436	5/14/2038 0:00	5247	159.6334	6/29/2038 0:00	5293	159.7225
2/12/2038 0:00	5156	159.455	3/30/2038 0:00	5202	159.5456	5/15/2038 0:00	5248	159.6354	6/30/2038 0:00	5294	159.7244
2/13/2038 0:00	5157	159.457	3/31/2038 0:00	5203	159.5476	5/16/2038 0:00	5249	159.6373	7/1/2038 0:00	5295	159.7263
2/14/2038 0:00	5158	159.459	4/1/2038 0:00	5204	159.5495	5/17/2038 0:00	5250	159.6393	7/2/2038 0:00	5296	159.7282
2/15/2038 0:00	5159	159.461	4/2/2038 0:00	5205	159.5515	5/18/2038 0:00	5251	159.6412	7/3/2038 0:00	5297	159.7302
2/16/2038 0:00	5160	159.4629	4/3/2038 0:00	5206	159.5534	5/19/2038 0:00	5252	159.6432	7/4/2038 0:00	5298	159.7321
2/17/2038 0:00	5161	159.4649	4/4/2038 0:00	5207	159.5554	5/20/2038 0:00	5253	159.6451	7/5/2038 0:00	5299	159.734
2/18/2038 0:00	5162	159.4669	4/5/2038 0:00	5208	159.5574	5/21/2038 0:00	5254	159.647	7/6/2038 0:00	5300	159.7359
2/19/2038 0:00	5163	159.4689	4/6/2038 0:00	5209	159.5593	5/22/2038 0:00	5255	159.649	7/7/2038 0:00	5301	159.7379
2/20/2038 0:00	5164	159.4708	4/7/2038 0:00	5210	159.5613	5/23/2038 0:00	5256	159.6509	7/8/2038 0:00	5302	159.7398
2/21/2038 0:00	5165	159.4728	4/8/2038 0:00	5211	159.5632	5/24/2038 0:00	5257	159.6529	7/9/2038 0:00	5303	159.7417
2/22/2038 0:00	5166	159.4748	4/9/2038 0:00	5212	159.5652	5/25/2038 0:00	5258	159.6548	7/10/2038 0:00	5304	159.7436
2/23/2038 0:00	5167	159.4768	4/10/2038 0:00	5213	159.5671	5/26/2038 0:00	5259	159.6567	7/11/2038 0:00	5305	159.7456
2/24/2038 0:00	5168	159.4787	4/11/2038 0:00	5214	159.5691	5/27/2038 0:00	5260	159.6587	7/12/2038 0:00	5306	159.7475
2/25/2038 0:00	5169	159.4807	4/12/2038 0:00	5215	159.5711	5/28/2038 0:00	5261	159.6606	7/13/2038 0:00	5307	159.7494
2/26/2038 0:00	5170	159.4827	4/13/2038 0:00	5216	159.573	5/29/2038 0:00	5262	159.6626	7/14/2038 0:00	5308	159.7513
2/27/2038 0:00	5171	159.4847	4/14/2038 0:00	5217	159.575	5/30/2038 0:00	5263	159.6645	7/15/2038 0:00	5309	159.7532
2/28/2038 0:00	5172	159.4866	4/15/2038 0:00	5218	159.5769	5/31/2038 0:00	5264	159.6664	7/16/2038 0:00	5310	159.7552
3/1/2038 0:00	5173	159.4886	4/16/2038 0:00	5219	159.5789	6/1/2038 0:00	5265	159.6684	7/17/2038 0:00	5311	159.7571
3/2/2038 0:00	5174	159.4906	4/17/2038 0:00	5220	159.5808	6/2/2038 0:00	5266	159.6703	7/18/2038 0:00	5312	159.759
3/3/2038 0:00	5175	159.4925	4/18/2038 0:00	5221	159.5828	6/3/2038 0:00	5267	159.6722	7/19/2038 0:00	5313	159.7609
3/4/2038 0:00	5176	159.4945	4/19/2038 0:00	5222	159.5847	6/4/2038 0:00	5268	159.6742	7/20/2038 0:00	5314	159.7628
3/5/2038 0:00	5177	159.4965	4/20/2038 0:00	5223	159.5867	6/5/2038 0:00	5269	159.6761	7/21/2038 0:00	5315	159.7648
3/6/2038 0:00	5178	159.4985	4/21/2038 0:00	5224	159.5886	6/6/2038 0:00	5270	159.678	7/22/2038 0:00	5316	159.7667
3/7/2038 0:00	5179	159.5004	4/22/2038 0:00	5225	159.5906	6/7/2038 0:00	5271	159.68	7/23/2038 0:00	5317	159.7686
3/8/2038 0:00	5180	159.5024	4/23/2038 0:00	5226	159.5925	6/8/2038 0:00	5272	159.6819	7/24/2038 0:00	5318	159.7705
3/9/2038 0:00	5181	159.5044	4/24/2038 0:00	5227	159.5945	6/9/2038 0:00	5273	159.6839	7/25/2038 0:00	5319	159.7724
3/10/2038 0:00	5182	159.5063	4/25/2038 0:00	5228	159.5964	6/10/2038 0:00	5274	159.6858	7/26/2038 0:00	5320	159.7743
3/11/2038 0:00	5183	159.5083	4/26/2038 0:00	5229	159.5984	6/11/2038 0:00	5275	159.6877	7/27/2038 0:00	5321	159.7763
3/12/2038 0:00	5184	159.5103	4/27/2038 0:00	5230	159.6003	6/12/2038 0:00	5276	159.6897	7/28/2038 0:00	5322	159.7782
3/13/2038 0:00	5185	159.5122	4/28/2038 0:00	5231	159.6023	6/13/2038 0:00	5277	159.6916	7/29/2038 0:00	5323	159.7801

7/30/2038 0:00	5324	159.782	9/14/2038 0:00	5370	159.8697	10/30/2038 0:00	5416	159.9567	12/15/2038 0:00	5462	160.043
7/31/2038 0:00	5325	159.7839	9/15/2038 0:00	5371	159.8716	10/31/2038 0:00	5417	159.9586	12/16/2038 0:00	5463	160.0448
8/1/2038 0:00	5326	159.7858	9/16/2038 0:00	5372	159.8735	11/1/2038 0:00	5418	159.9605	12/17/2038 0:00	5464	160.0467
8/2/2038 0:00	5327	159.7878	9/17/2038 0:00	5373	159.8754	11/2/2038 0:00	5419	159.9624	12/18/2038 0:00	5465	160.0486
8/3/2038 0:00	5328	159.7897	9/18/2038 0:00	5374	159.8773	11/3/2038 0:00	5420	159.9643	12/19/2038 0:00	5466	160.0504
8/4/2038 0:00	5329	159.7916	9/19/2038 0:00	5375	159.8792	11/4/2038 0:00	5421	159.9661	12/20/2038 0:00	5467	160.0523
8/5/2038 0:00	5330	159.7935	9/20/2038 0:00	5376	159.8811	11/5/2038 0:00	5422	159.968	12/21/2038 0:00	5468	160.0542
8/6/2038 0:00	5331	159.7954	9/21/2038 0:00	5377	159.883	11/6/2038 0:00	5423	159.9699	12/22/2038 0:00	5469	160.056
8/7/2038 0:00	5332	159.7973	9/22/2038 0:00	5378	159.8849	11/7/2038 0:00	5424	159.9718	12/23/2038 0:00	5470	160.0579
8/8/2038 0:00	5333	159.7992	9/23/2038 0:00	5379	159.8868	11/8/2038 0:00	5425	159.9737	12/24/2038 0:00	5471	160.0598
8/9/2038 0:00	5334	159.8011	9/24/2038 0:00	5380	159.8887	11/9/2038 0:00	5426	159.9755	12/25/2038 0:00	5472	160.0616
8/10/2038 0:00	5335	159.8031	9/25/2038 0:00	5381	159.8906	11/10/2038 0:00	5427	159.9774	12/26/2038 0:00	5473	160.0635
8/11/2038 0:00	5336	159.805	9/26/2038 0:00	5382	159.8925	11/11/2038 0:00	5428	159.9793	12/27/2038 0:00	5474	160.0654
8/12/2038 0:00	5337	159.8069	9/27/2038 0:00	5383	159.8944	11/12/2038 0:00	5429	159.9812	12/28/2038 0:00	5475	160.0672
8/13/2038 0:00	5338	159.8088	9/28/2038 0:00	5384	159.8963	11/13/2038 0:00	5430	159.9831	12/29/2038 0:00	5476	160.0691
8/14/2038 0:00	5339	159.8107	9/29/2038 0:00	5385	159.8982	11/14/2038 0:00	5431	159.9849	12/30/2038 0:00	5477	160.0709
8/15/2038 0:00	5340	159.8126	9/30/2038 0:00	5386	159.9001	11/15/2038 0:00	5432	159.9868	12/31/2038 0:00	5478	160.0728
8/16/2038 0:00	5341	159.8145	10/1/2038 0:00	5387	159.902	11/16/2038 0:00	5433	159.9887	1/1/2039 0:00	5479	160.0747
8/17/2038 0:00	5342	159.8164	10/2/2038 0:00	5388	159.9039	11/17/2038 0:00	5434	159.9906	1/2/2039 0:00	5480	160.0765
8/18/2038 0:00	5343	159.8183	10/3/2038 0:00	5389	159.9058	11/18/2038 0:00	5435	159.9924	1/3/2039 0:00	5481	160.0784
8/19/2038 0:00	5344	159.8202	10/4/2038 0:00	5390	159.9077	11/19/2038 0:00	5436	159.9943	1/4/2039 0:00	5482	160.0802
8/20/2038 0:00	5345	159.8222	10/5/2038 0:00	5391	159.9095	11/20/2038 0:00	5437	159.9962	1/5/2039 0:00	5483	160.0821
8/21/2038 0:00	5346	159.8241	10/6/2038 0:00	5392	159.9114	11/21/2038 0:00	5438	159.9981	1/6/2039 0:00	5484	160.084
8/22/2038 0:00	5347	159.826	10/7/2038 0:00	5393	159.9133	11/22/2038 0:00	5439	159.9999	1/7/2039 0:00	5485	160.0858
8/23/2038 0:00	5348	159.8279	10/8/2038 0:00	5394	159.9152	11/23/2038 0:00	5440	160.0018	1/8/2039 0:00	5486	160.0877
8/24/2038 0:00	5349	159.8298	10/9/2038 0:00	5395	159.9171	11/24/2038 0:00	5441	160.0037	1/9/2039 0:00	5487	160.0895
8/25/2038 0:00	5350	159.8317	10/10/2038 0:00	5396	159.919	11/25/2038 0:00	5442	160.0056	1/10/2039 0:00	5488	160.0914
8/26/2038 0:00	5351	159.8336	10/11/2038 0:00	5397	159.9209	11/26/2038 0:00	5443	160.0074	1/11/2039 0:00	5489	160.0933
8/27/2038 0:00	5352	159.8355	10/12/2038 0:00	5398	159.9228	11/27/2038 0:00	5444	160.0093	1/12/2039 0:00	5490	160.0951
8/28/2038 0:00	5353	159.8374	10/13/2038 0:00	5399	159.9247	11/28/2038 0:00	5445	160.0112	1/13/2039 0:00	5491	160.097
8/29/2038 0:00	5354	159.8393	10/14/2038 0:00	5400	159.9266	11/29/2038 0:00	5446	160.0131	1/14/2039 0:00	5492	160.0988
8/30/2038 0:00	5355	159.8412	10/15/2038 0:00	5401	159.9284	11/30/2038 0:00	5447	160.0149	1/15/2039 0:00	5493	160.1007
8/31/2038 0:00	5356	159.8431	10/16/2038 0:00	5402	159.9303	12/1/2038 0:00	5448	160.0168	1/16/2039 0:00	5494	160.1025
9/1/2038 0:00	5357	159.845	10/17/2038 0:00	5403	159.9322	12/2/2038 0:00	5449	160.0187	1/17/2039 0:00	5495	160.1044
9/2/2038 0:00	5358	159.8469	10/18/2038 0:00	5404	159.9341	12/3/2038 0:00	5450	160.0205	1/18/2039 0:00	5496	160.1063
9/3/2038 0:00	5359	159.8488	10/19/2038 0:00	5405	159.936	12/4/2038 0:00	5451	160.0224	1/19/2039 0:00	5497	160.1081
9/4/2038 0:00	5360	159.8507	10/20/2038 0:00	5406	159.9379	12/5/2038 0:00	5452	160.0243	1/20/2039 0:00	5498	160.11
9/5/2038 0:00	5361	159.8526	10/21/2038 0:00	5407	159.9398	12/6/2038 0:00	5453	160.0262	1/21/2039 0:00	5499	160.1118
9/6/2038 0:00	5362	159.8545	10/22/2038 0:00	5408	159.9417	12/7/2038 0:00	5454	160.028	1/22/2039 0:00	5500	160.1137
9/7/2038 0:00	5363	159.8564	10/23/2038 0:00	5409	159.9435	12/8/2038 0:00	5455	160.0299	1/23/2039 0:00	5501	160.1155
9/8/2038 0:00	5364	159.8583	10/24/2038 0:00	5410	159.9454	12/9/2038 0:00	5456	160.0318	1/24/2039 0:00	5502	160.1174
9/9/2038 0:00	5365	159.8602	10/25/2038 0:00	5411	159.9473	12/10/2038 0:00	5457	160.0336	1/25/2039 0:00	5503	160.1192
9/10/2038 0:00	5366	159.8621	10/26/2038 0:00	5412	159.9492	12/11/2038 0:00	5458	160.0355	1/26/2039 0:00	5504	160.1211
9/11/2038 0:00	5367	159.864	10/27/2038 0:00	5413	159.9511	12/12/2038 0:00	5459	160.0374	1/27/2039 0:00	5505	160.1229
9/12/2038 0:00	5368	159.8659	10/28/2038 0:00	5414	159.953	12/13/2038 0:00	5460	160.0392	1/28/2039 0:00	5506	160.1248
9/13/2038 0:00	5369	159.8678	10/29/2038 0:00	5415	159.9548	12/14/2038 0:00	5461	160.0411	1/29/2039 0:00	5507	160.1267

1/30/2039 0:00	5508	160.1285	3/17/2039 0:00	5554	160.2133	5/2/2039 0:00	5600	160.2974	6/17/2039 0:00	5646	160.3809
1/31/2039 0:00	5509	160.1304	3/18/2039 0:00	5555	160.2152	5/3/2039 0:00	5601	160.2993	6/18/2039 0:00	5647	160.3827
2/1/2039 0:00	5510	160.1322	3/19/2039 0:00	5556	160.217	5/4/2039 0:00	5602	160.3011	6/19/2039 0:00	5648	160.3845
2/2/2039 0:00	5511	160.1341	3/20/2039 0:00	5557	160.2188	5/5/2039 0:00	5603	160.3029	6/20/2039 0:00	5649	160.3863
2/3/2039 0:00	5512	160.1359	3/21/2039 0:00	5558	160.2207	5/6/2039 0:00	5604	160.3047	6/21/2039 0:00	5650	160.3881
2/4/2039 0:00	5513	160.1378	3/22/2039 0:00	5559	160.2225	5/7/2039 0:00	5605	160.3065	6/22/2039 0:00	5651	160.3899
2/5/2039 0:00	5514	160.1396	3/23/2039 0:00	5560	160.2243	5/8/2039 0:00	5606	160.3084	6/23/2039 0:00	5652	160.3917
2/6/2039 0:00	5515	160.1415	3/24/2039 0:00	5561	160.2262	5/9/2039 0:00	5607	160.3102	6/24/2039 0:00	5653	160.3935
2/7/2039 0:00	5516	160.1433	3/25/2039 0:00	5562	160.228	5/10/2039 0:00	5608	160.312	6/25/2039 0:00	5654	160.3953
2/8/2039 0:00	5517	160.1452	3/26/2039 0:00	5563	160.2298	5/11/2039 0:00	5609	160.3138	6/26/2039 0:00	5655	160.3971
2/9/2039 0:00	5518	160.147	3/27/2039 0:00	5564	160.2317	5/12/2039 0:00	5610	160.3156	6/27/2039 0:00	5656	160.3989
2/10/2039 0:00	5519	160.1488	3/28/2039 0:00	5565	160.2335	5/13/2039 0:00	5611	160.3174	6/28/2039 0:00	5657	160.4007
2/11/2039 0:00	5520	160.1507	3/29/2039 0:00	5566	160.2353	5/14/2039 0:00	5612	160.3193	6/29/2039 0:00	5658	160.4025
2/12/2039 0:00	5521	160.1525	3/30/2039 0:00	5567	160.2372	5/15/2039 0:00	5613	160.3211	6/30/2039 0:00	5659	160.4043
2/13/2039 0:00	5522	160.1544	3/31/2039 0:00	5568	160.239	5/16/2039 0:00	5614	160.3229	7/1/2039 0:00	5660	160.4061
2/14/2039 0:00	5523	160.1562	4/1/2039 0:00	5569	160.2408	5/17/2039 0:00	5615	160.3247	7/2/2039 0:00	5661	160.4079
2/15/2039 0:00	5524	160.1581	4/2/2039 0:00	5570	160.2427	5/18/2039 0:00	5616	160.3265	7/3/2039 0:00	5662	160.4097
2/16/2039 0:00	5525	160.1599	4/3/2039 0:00	5571	160.2445	5/19/2039 0:00	5617	160.3283	7/4/2039 0:00	5663	160.4115
2/17/2039 0:00	5526	160.1618	4/4/2039 0:00	5572	160.2463	5/20/2039 0:00	5618	160.3302	7/5/2039 0:00	5664	160.4133
2/18/2039 0:00	5527	160.1636	4/5/2039 0:00	5573	160.2481	5/21/2039 0:00	5619	160.332	7/6/2039 0:00	5665	160.4151
2/19/2039 0:00	5528	160.1655	4/6/2039 0:00	5574	160.25	5/22/2039 0:00	5620	160.3338	7/7/2039 0:00	5666	160.4169
2/20/2039 0:00	5529	160.1673	4/7/2039 0:00	5575	160.2518	5/23/2039 0:00	5621	160.3356	7/8/2039 0:00	5667	160.4187
2/21/2039 0:00	5530	160.1692	4/8/2039 0:00	5576	160.2536	5/24/2039 0:00	5622	160.3374	7/9/2039 0:00	5668	160.4205
2/22/2039 0:00	5531	160.171	4/9/2039 0:00	5577	160.2555	5/25/2039 0:00	5623	160.3392	7/10/2039 0:00	5669	160.4223
2/23/2039 0:00	5532	160.1728	4/10/2039 0:00	5578	160.2573	5/26/2039 0:00	5624	160.341	7/11/2039 0:00	5670	160.4241
2/24/2039 0:00	5533	160.1747	4/11/2039 0:00	5579	160.2591	5/27/2039 0:00	5625	160.3429	7/12/2039 0:00	5671	160.4259
2/25/2039 0:00	5534	160.1765	4/12/2039 0:00	5580	160.2609	5/28/2039 0:00	5626	160.3447	7/13/2039 0:00	5672	160.4277
2/26/2039 0:00	5535	160.1784	4/13/2039 0:00	5581	160.2628	5/29/2039 0:00	5627	160.3465	7/14/2039 0:00	5673	160.4295
2/27/2039 0:00	5536	160.1802	4/14/2039 0:00	5582	160.2646	5/30/2039 0:00	5628	160.3483	7/15/2039 0:00	5674	160.4313
2/28/2039 0:00	5537	160.1821	4/15/2039 0:00	5583	160.2664	5/31/2039 0:00	5629	160.3501	7/16/2039 0:00	5675	160.4331
3/1/2039 0:00	5538	160.1839	4/16/2039 0:00	5584	160.2683	6/1/2039 0:00	5630	160.3519	7/17/2039 0:00	5676	160.4349
3/2/2039 0:00	5539	160.1857	4/17/2039 0:00	5585	160.2701	6/2/2039 0:00	5631	160.3537	7/18/2039 0:00	5677	160.4367
3/3/2039 0:00	5540	160.1876	4/18/2039 0:00	5586	160.2719	6/3/2039 0:00	5632	160.3555	7/19/2039 0:00	5678	160.4385
3/4/2039 0:00	5541	160.1894	4/19/2039 0:00	5587	160.2737	6/4/2039 0:00	5633	160.3574	7/20/2039 0:00	5679	160.4403
3/5/2039 0:00	5542	160.1913	4/20/2039 0:00	5588	160.2756	6/5/2039 0:00	5634	160.3592	7/21/2039 0:00	5680	160.4421
3/6/2039 0:00	5543	160.1931	4/21/2039 0:00	5589	160.2774	6/6/2039 0:00	5635	160.361	7/22/2039 0:00	5681	160.4439
3/7/2039 0:00	5544	160.1949	4/22/2039 0:00	5590	160.2792	6/7/2039 0:00	5636	160.3628	7/23/2039 0:00	5682	160.4457
3/8/2039 0:00	5545	160.1968	4/23/2039 0:00	5591	160.281	6/8/2039 0:00	5637	160.3646	7/24/2039 0:00	5683	160.4475
3/9/2039 0:00	5546	160.1986	4/24/2039 0:00	5592	160.2829	6/9/2039 0:00	5638	160.3664	7/25/2039 0:00	5684	160.4493
3/10/2039 0:00	5547	160.2005	4/25/2039 0:00	5593	160.2847	6/10/2039 0:00	5639	160.3682	7/26/2039 0:00	5685	160.4511
3/11/2039 0:00	5548	160.2023	4/26/2039 0:00	5594	160.2865	6/11/2039 0:00	5640	160.37	7/27/2039 0:00	5686	160.4529
3/12/2039 0:00	5549	160.2041	4/27/2039 0:00	5595	160.2883	6/12/2039 0:00	5641	160.3718	7/28/2039 0:00	5687	160.4547
3/13/2039 0:00	5550	160.206	4/28/2039 0:00	5596	160.2901	6/13/2039 0:00	5642	160.3736	7/29/2039 0:00	5688	160.4564
3/14/2039 0:00	5551	160.2078	4/29/2039 0:00	5597	160.292	6/14/2039 0:00	5643	160.3754	7/30/2039 0:00	5689	160.4582
3/15/2039 0:00	5552	160.2096	4/30/2039 0:00	5598	160.2938	6/15/2039 0:00	5644	160.3773	7/31/2039 0:00	5690	160.46
3/16/2039 0:00	5553	160.2115	5/1/2039 0:00	5599	160.2956	6/16/2039 0:00	5645	160.3791	8/1/2039 0:00	5691	160.4618

8/2/2039 0:00	5692	160.4636	9/17/2039 0:00	5738	160.5457	11/2/2039 0:00	5784	160.6271	12/18/2039 0:00	5830	160.7079
8/3/2039 0:00	5693	160.4654	9/18/2039 0:00	5739	160.5475	11/3/2039 0:00	5785	160.6289	12/19/2039 0:00	5831	160.7097
8/4/2039 0:00	5694	160.4672	9/19/2039 0:00	5740	160.5493	11/4/2039 0:00	5786	160.6307	12/20/2039 0:00	5832	160.7114
8/5/2039 0:00	5695	160.469	9/20/2039 0:00	5741	160.551	11/5/2039 0:00	5787	160.6324	12/21/2039 0:00	5833	160.7132
8/6/2039 0:00	5696	160.4708	9/21/2039 0:00	5742	160.5528	11/6/2039 0:00	5788	160.6342	12/22/2039 0:00	5834	160.7149
8/7/2039 0:00	5697	160.4726	9/22/2039 0:00	5743	160.5546	11/7/2039 0:00	5789	160.6359	12/23/2039 0:00	5835	160.7167
8/8/2039 0:00	5698	160.4744	9/23/2039 0:00	5744	160.5564	11/8/2039 0:00	5790	160.6377	12/24/2039 0:00	5836	160.7184
8/9/2039 0:00	5699	160.4762	9/24/2039 0:00	5745	160.5581	11/9/2039 0:00	5791	160.6395	12/25/2039 0:00	5837	160.7202
8/10/2039 0:00	5700	160.4779	9/25/2039 0:00	5746	160.5599	11/10/2039 0:00	5792	160.6412	12/26/2039 0:00	5838	160.7219
8/11/2039 0:00	5701	160.4797	9/26/2039 0:00	5747	160.5617	11/11/2039 0:00	5793	160.643	12/27/2039 0:00	5839	160.7237
8/12/2039 0:00	5702	160.4815	9/27/2039 0:00	5748	160.5635	11/12/2039 0:00	5794	160.6448	12/28/2039 0:00	5840	160.7254
8/13/2039 0:00	5703	160.4833	9/28/2039 0:00	5749	160.5652	11/13/2039 0:00	5795	160.6465	12/29/2039 0:00	5841	160.7271
8/14/2039 0:00	5704	160.4851	9/29/2039 0:00	5750	160.567	11/14/2039 0:00	5796	160.6483	12/30/2039 0:00	5842	160.7289
8/15/2039 0:00	5705	160.4869	9/30/2039 0:00	5751	160.5688	11/15/2039 0:00	5797	160.65	12/31/2039 0:00	5843	160.7306
8/16/2039 0:00	5706	160.4887	10/1/2039 0:00	5752	160.5706	11/16/2039 0:00	5798	160.6518	1/1/2040 0:00	5844	160.7324
8/17/2039 0:00	5707	160.4905	10/2/2039 0:00	5753	160.5723	11/17/2039 0:00	5799	160.6536	1/2/2040 0:00	5845	160.7341
8/18/2039 0:00	5708	160.4922	10/3/2039 0:00	5754	160.5741	11/18/2039 0:00	5800	160.6553	1/3/2040 0:00	5846	160.7359
8/19/2039 0:00	5709	160.494	10/4/2039 0:00	5755	160.5759	11/19/2039 0:00	5801	160.6571	1/4/2040 0:00	5847	160.7376
8/20/2039 0:00	5710	160.4958	10/5/2039 0:00	5756	160.5776	11/20/2039 0:00	5802	160.6588	1/5/2040 0:00	5848	160.7394
8/21/2039 0:00	5711	160.4976	10/6/2039 0:00	5757	160.5794	11/21/2039 0:00	5803	160.6606	1/6/2040 0:00	5849	160.7411
8/22/2039 0:00	5712	160.4994	10/7/2039 0:00	5758	160.5812	11/22/2039 0:00	5804	160.6623	1/7/2040 0:00	5850	160.7429
8/23/2039 0:00	5713	160.5012	10/8/2039 0:00	5759	160.583	11/23/2039 0:00	5805	160.6641	1/8/2040 0:00	5851	160.7446
8/24/2039 0:00	5714	160.503	10/9/2039 0:00	5760	160.5847	11/24/2039 0:00	5806	160.6659	1/9/2040 0:00	5852	160.7463
8/25/2039 0:00	5715	160.5047	10/10/2039 0:00	5761	160.5865	11/25/2039 0:00	5807	160.6676	1/10/2040 0:00	5853	160.7481
8/26/2039 0:00	5716	160.5065	10/11/2039 0:00	5762	160.5883	11/26/2039 0:00	5808	160.6694	1/11/2040 0:00	5854	160.7498
8/27/2039 0:00	5717	160.5083	10/12/2039 0:00	5763	160.59	11/27/2039 0:00	5809	160.6711	1/12/2040 0:00	5855	160.7516
8/28/2039 0:00	5718	160.5101	10/13/2039 0:00	5764	160.5918	11/28/2039 0:00	5810	160.6729	1/13/2040 0:00	5856	160.7533
8/29/2039 0:00	5719	160.5119	10/14/2039 0:00	5765	160.5936	11/29/2039 0:00	5811	160.6746	1/14/2040 0:00	5857	160.755
8/30/2039 0:00	5720	160.5137	10/15/2039 0:00	5766	160.5953	11/30/2039 0:00	5812	160.6764	1/15/2040 0:00	5858	160.7568
8/31/2039 0:00	5721	160.5154	10/16/2039 0:00	5767	160.5971	12/1/2039 0:00	5813	160.6781	1/16/2040 0:00	5859	160.7585
9/1/2039 0:00	5722	160.5172	10/17/2039 0:00	5768	160.5989	12/2/2039 0:00	5814	160.6799	1/17/2040 0:00	5860	160.7603
9/2/2039 0:00	5723	160.519	10/18/2039 0:00	5769	160.6007	12/3/2039 0:00	5815	160.6817	1/18/2040 0:00	5861	160.762
9/3/2039 0:00	5724	160.5208	10/19/2039 0:00	5770	160.6024	12/4/2039 0:00	5816	160.6834	1/19/2040 0:00	5862	160.7637
9/4/2039 0:00	5725	160.5226	10/20/2039 0:00	5771	160.6042	12/5/2039 0:00	5817	160.6852	1/20/2040 0:00	5863	160.7655
9/5/2039 0:00	5726	160.5244	10/21/2039 0:00	5772	160.606	12/6/2039 0:00	5818	160.6869	1/21/2040 0:00	5864	160.7672
9/6/2039 0:00	5727	160.5261	10/22/2039 0:00	5773	160.6077	12/7/2039 0:00	5819	160.6887	1/22/2040 0:00	5865	160.769
9/7/2039 0:00	5728	160.5279	10/23/2039 0:00	5774	160.6095	12/8/2039 0:00	5820	160.6904	1/23/2040 0:00	5866	160.7707
9/8/2039 0:00	5729	160.5297	10/24/2039 0:00	5775	160.6113	12/9/2039 0:00	5821	160.6922	1/24/2040 0:00	5867	160.7724
9/9/2039 0:00	5730	160.5315	10/25/2039 0:00	5776	160.613	12/10/2039 0:00	5822	160.6939	1/25/2040 0:00	5868	160.7742
9/10/2039 0:00	5731	160.5333	10/26/2039 0:00	5777	160.6148	12/11/2039 0:00	5823	160.6957	1/26/2040 0:00	5869	160.7759
9/11/2039 0:00	5732	160.535	10/27/2039 0:00	5778	160.6166	12/12/2039 0:00	5824	160.6974	1/27/2040 0:00	5870	160.7777
9/12/2039 0:00	5733	160.5368	10/28/2039 0:00	5779	160.6183	12/13/2039 0:00	5825	160.6992	1/28/2040 0:00	5871	160.7794
9/13/2039 0:00	5734	160.5386	10/29/2039 0:00	5780	160.6201	12/14/2039 0:00	5826	160.7009	1/29/2040 0:00	5872	160.7811
9/14/2039 0:00	5735	160.5404	10/30/2039 0:00	5781	160.6218	12/15/2039 0:00	5827	160.7027	1/30/2040 0:00	5873	160.7829
9/15/2039 0:00	5736	160.5421	10/31/2039 0:00	5782	160.6236	12/16/2039 0:00	5828	160.7044	1/31/2040 0:00	5874	160.7846
9/16/2039 0:00	5737	160.5439	11/1/2039 0:00	5783	160.6254	12/17/2039 0:00	5829	160.7062	2/1/2040 0:00	5875	160.7863

2/2/2040 0:00	5876	160.7881	3/19/2040 0:00	5922	160.8676	5/4/2040 0:00	5968	160.9465	6/19/2040 0:00	6014	161.0248
2/3/2040 0:00	5877	160.7898	3/20/2040 0:00	5923	160.8693	5/5/2040 0:00	5969	160.9482	6/20/2040 0:00	6015	161.0265
2/4/2040 0:00	5878	160.7915	3/21/2040 0:00	5924	160.871	5/6/2040 0:00	5970	160.9499	6/21/2040 0:00	6016	161.0282
2/5/2040 0:00	5879	160.7933	3/22/2040 0:00	5925	160.8728	5/7/2040 0:00	5971	160.9516	6/22/2040 0:00	6017	161.0299
2/6/2040 0:00	5880	160.795	3/23/2040 0:00	5926	160.8745	5/8/2040 0:00	5972	160.9534	6/23/2040 0:00	6018	161.0316
2/7/2040 0:00	5881	160.7968	3/24/2040 0:00	5927	160.8762	5/9/2040 0:00	5973	160.9551	6/24/2040 0:00	6019	161.0333
2/8/2040 0:00	5882	160.7985	3/25/2040 0:00	5928	160.8779	5/10/2040 0:00	5974	160.9568	6/25/2040 0:00	6020	161.035
2/9/2040 0:00	5883	160.8002	3/26/2040 0:00	5929	160.8797	5/11/2040 0:00	5975	160.9585	6/26/2040 0:00	6021	161.0367
2/10/2040 0:00	5884	160.802	3/27/2040 0:00	5930	160.8814	5/12/2040 0:00	5976	160.9602	6/27/2040 0:00	6022	161.0384
2/11/2040 0:00	5885	160.8037	3/28/2040 0:00	5931	160.8831	5/13/2040 0:00	5977	160.9619	6/28/2040 0:00	6023	161.0401
2/12/2040 0:00	5886	160.8054	3/29/2040 0:00	5932	160.8848	5/14/2040 0:00	5978	160.9636	6/29/2040 0:00	6024	161.0418
2/13/2040 0:00	5887	160.8072	3/30/2040 0:00	5933	160.8865	5/15/2040 0:00	5979	160.9653	6/30/2040 0:00	6025	161.0435
2/14/2040 0:00	5888	160.8089	3/31/2040 0:00	5934	160.8882	5/16/2040 0:00	5980	160.967	7/1/2040 0:00	6026	161.0452
2/15/2040 0:00	5889	160.8106	4/1/2040 0:00	5935	160.89	5/17/2040 0:00	5981	160.9687	7/2/2040 0:00	6027	161.0468
2/16/2040 0:00	5890	160.8123	4/2/2040 0:00	5936	160.8917	5/18/2040 0:00	5982	160.9704	7/3/2040 0:00	6028	161.0485
2/17/2040 0:00	5891	160.8141	4/3/2040 0:00	5937	160.8934	5/19/2040 0:00	5983	160.9721	7/4/2040 0:00	6029	161.0502
2/18/2040 0:00	5892	160.8158	4/4/2040 0:00	5938	160.8951	5/20/2040 0:00	5984	160.9738	7/5/2040 0:00	6030	161.0519
2/19/2040 0:00	5893	160.8175	4/5/2040 0:00	5939	160.8968	5/21/2040 0:00	5985	160.9755	7/6/2040 0:00	6031	161.0536
2/20/2040 0:00	5894	160.8193	4/6/2040 0:00	5940	160.8986	5/22/2040 0:00	5986	160.9772	7/7/2040 0:00	6032	161.0553
2/21/2040 0:00	5895	160.821	4/7/2040 0:00	5941	160.9003	5/23/2040 0:00	5987	160.9789	7/8/2040 0:00	6033	161.057
2/22/2040 0:00	5896	160.8227	4/8/2040 0:00	5942	160.902	5/24/2040 0:00	5988	160.9806	7/9/2040 0:00	6034	161.0587
2/23/2040 0:00	5897	160.8245	4/9/2040 0:00	5943	160.9037	5/25/2040 0:00	5989	160.9823	7/10/2040 0:00	6035	161.0604
2/24/2040 0:00	5898	160.8262	4/10/2040 0:00	5944	160.9054	5/26/2040 0:00	5990	160.984	7/11/2040 0:00	6036	161.0621
2/25/2040 0:00	5899	160.8279	4/11/2040 0:00	5945	160.9071	5/27/2040 0:00	5991	160.9857	7/12/2040 0:00	6037	161.0638
2/26/2040 0:00	5900	160.8296	4/12/2040 0:00	5946	160.9089	5/28/2040 0:00	5992	160.9874	7/13/2040 0:00	6038	161.0654
2/27/2040 0:00	5901	160.8314	4/13/2040 0:00	5947	160.9106	5/29/2040 0:00	5993	160.9892	7/14/2040 0:00	6039	161.0671
2/28/2040 0:00	5902	160.8331	4/14/2040 0:00	5948	160.9123	5/30/2040 0:00	5994	160.9909	7/15/2040 0:00	6040	161.0688
2/29/2040 0:00	5903	160.8348	4/15/2040 0:00	5949	160.914	5/31/2040 0:00	5995	160.9926	7/16/2040 0:00	6041	161.0705
3/1/2040 0:00	5904	160.8366	4/16/2040 0:00	5950	160.9157	6/1/2040 0:00	5996	160.9943	7/17/2040 0:00	6042	161.0722
3/2/2040 0:00	5905	160.8383	4/17/2040 0:00	5951	160.9174	6/2/2040 0:00	5997	160.996	7/18/2040 0:00	6043	161.0739
3/3/2040 0:00	5906	160.84	4/18/2040 0:00	5952	160.9191	6/3/2040 0:00	5998	160.9977	7/19/2040 0:00	6044	161.0756
3/4/2040 0:00	5907	160.8417	4/19/2040 0:00	5953	160.9209	6/4/2040 0:00	5999	160.9994	7/20/2040 0:00	6045	161.0773
3/5/2040 0:00	5908	160.8435	4/20/2040 0:00	5954	160.9226	6/5/2040 0:00	6000	161.0011	7/21/2040 0:00	6046	161.0789
3/6/2040 0:00	5909	160.8452	4/21/2040 0:00	5955	160.9243	6/6/2040 0:00	6001	161.0028	7/22/2040 0:00	6047	161.0806
3/7/2040 0:00	5910	160.8469	4/22/2040 0:00	5956	160.926	6/7/2040 0:00	6002	161.0045	7/23/2040 0:00	6048	161.0823
3/8/2040 0:00	5911	160.8486	4/23/2040 0:00	5957	160.9277	6/8/2040 0:00	6003	161.0062	7/24/2040 0:00	6049	161.084
3/9/2040 0:00	5912	160.8504	4/24/2040 0:00	5958	160.9294	6/9/2040 0:00	6004	161.0079	7/25/2040 0:00	6050	161.0857
3/10/2040 0:00	5913	160.8521	4/25/2040 0:00	5959	160.9311	6/10/2040 0:00	6005	161.0096	7/26/2040 0:00	6051	161.0874
3/11/2040 0:00	5914	160.8538	4/26/2040 0:00	5960	160.9328	6/11/2040 0:00	6006	161.0113	7/27/2040 0:00	6052	161.0891
3/12/2040 0:00	5915	160.8555	4/27/2040 0:00	5961	160.9345	6/12/2040 0:00	6007	161.0129	7/28/2040 0:00	6053	161.0907
3/13/2040 0:00	5916	160.8573	4/28/2040 0:00	5962	160.9363	6/13/2040 0:00	6008	161.0146	7/29/2040 0:00	6054	161.0924
3/14/2040 0:00	5917	160.859	4/29/2040 0:00	5963	160.938	6/14/2040 0:00	6009	161.0163	7/30/2040 0:00	6055	161.0941
3/15/2040 0:00	5918	160.8607	4/30/2040 0:00	5964	160.9397	6/15/2040 0:00	6010	161.018	7/31/2040 0:00	6056	161.0958
3/16/2040 0:00	5919	160.8624	5/1/2040 0:00	5965	160.9414	6/16/2040 0:00	6011	161.0197	8/1/2040 0:00	6057	161.0975
3/17/2040 0:00	5920	160.8642	5/2/2040 0:00	5966	160.9431	6/17/2040 0:00	6012	161.0214	8/2/2040 0:00	6058	161.0992
3/18/2040 0:00	5921	160.8659	5/3/2040 0:00	5967	160.9448	6/18/2040 0:00	6013	161.0231	8/3/2040 0:00	6059	161.1009

8/4/2040 0:00	6060	161.1025	9/19/2040 0:00	6106	161.1797	11/4/2040 0:00	6152	161.2562	12/20/2040 0:00	6198	161.3322
8/5/2040 0:00	6061	161.1042	9/20/2040 0:00	6107	161.1813	11/5/2040 0:00	6153	161.2579	12/21/2040 0:00	6199	161.3338
8/6/2040 0:00	6062	161.1059	9/21/2040 0:00	6108	161.183	11/6/2040 0:00	6154	161.2595	12/22/2040 0:00	6200	161.3355
8/7/2040 0:00	6063	161.1076	9/22/2040 0:00	6109	161.1847	11/7/2040 0:00	6155	161.2612	12/23/2040 0:00	6201	161.3371
8/8/2040 0:00	6064	161.1093	9/23/2040 0:00	6110	161.1863	11/8/2040 0:00	6156	161.2628	12/24/2040 0:00	6202	161.3388
8/9/2040 0:00	6065	161.1109	9/24/2040 0:00	6111	161.188	11/9/2040 0:00	6157	161.2645	12/25/2040 0:00	6203	161.3404
8/10/2040 0:00	6066	161.1126	9/25/2040 0:00	6112	161.1897	11/10/2040 0:00	6158	161.2661	12/26/2040 0:00	6204	161.3421
8/11/2040 0:00	6067	161.1143	9/26/2040 0:00	6113	161.1913	11/11/2040 0:00	6159	161.2678	12/27/2040 0:00	6205	161.3437
8/12/2040 0:00	6068	161.116	9/27/2040 0:00	6114	161.193	11/12/2040 0:00	6160	161.2695	12/28/2040 0:00	6206	161.3453
8/13/2040 0:00	6069	161.1177	9/28/2040 0:00	6115	161.1947	11/13/2040 0:00	6161	161.2711	12/29/2040 0:00	6207	161.347
8/14/2040 0:00	6070	161.1194	9/29/2040 0:00	6116	161.1964	11/14/2040 0:00	6162	161.2728	12/30/2040 0:00	6208	161.3486
8/15/2040 0:00	6071	161.121	9/30/2040 0:00	6117	161.198	11/15/2040 0:00	6163	161.2744	12/31/2040 0:00	6209	161.3503
8/16/2040 0:00	6072	161.1227	10/1/2040 0:00	6118	161.1997	11/16/2040 0:00	6164	161.2761	1/1/2041 0:00	6210	161.3519
8/17/2040 0:00	6073	161.1244	10/2/2040 0:00	6119	161.2014	11/17/2040 0:00	6165	161.2777	1/2/2041 0:00	6211	161.3536
8/18/2040 0:00	6074	161.1261	10/3/2040 0:00	6120	161.203	11/18/2040 0:00	6166	161.2794	1/3/2041 0:00	6212	161.3552
8/19/2040 0:00	6075	161.1278	10/4/2040 0:00	6121	161.2047	11/19/2040 0:00	6167	161.281	1/4/2041 0:00	6213	161.3568
8/20/2040 0:00	6076	161.1294	10/5/2040 0:00	6122	161.2064	11/20/2040 0:00	6168	161.2827	1/5/2041 0:00	6214	161.3585
8/21/2040 0:00	6077	161.1311	10/6/2040 0:00	6123	161.208	11/21/2040 0:00	6169	161.2844	1/6/2041 0:00	6215	161.3601
8/22/2040 0:00	6078	161.1328	10/7/2040 0:00	6124	161.2097	11/22/2040 0:00	6170	161.286	1/7/2041 0:00	6216	161.3618
8/23/2040 0:00	6079	161.1345	10/8/2040 0:00	6125	161.2113	11/23/2040 0:00	6171	161.2877	1/8/2041 0:00	6217	161.3634
8/24/2040 0:00	6080	161.1361	10/9/2040 0:00	6126	161.213	11/24/2040 0:00	6172	161.2893	1/9/2041 0:00	6218	161.365
8/25/2040 0:00	6081	161.1378	10/10/2040 0:00	6127	161.2147	11/25/2040 0:00	6173	161.291	1/10/2041 0:00	6219	161.3667
8/26/2040 0:00	6082	161.1395	10/11/2040 0:00	6128	161.2163	11/26/2040 0:00	6174	161.2926	1/11/2041 0:00	6220	161.3683
8/27/2040 0:00	6083	161.1412	10/12/2040 0:00	6129	161.218	11/27/2040 0:00	6175	161.2943	1/12/2041 0:00	6221	161.37
8/28/2040 0:00	6084	161.1428	10/13/2040 0:00	6130	161.2197	11/28/2040 0:00	6176	161.2959	1/13/2041 0:00	6222	161.3716
8/29/2040 0:00	6085	161.1445	10/14/2040 0:00	6131	161.2213	11/29/2040 0:00	6177	161.2976	1/14/2041 0:00	6223	161.3732
8/30/2040 0:00	6086	161.1462	10/15/2040 0:00	6132	161.223	11/30/2040 0:00	6178	161.2992	1/15/2041 0:00	6224	161.3749
8/31/2040 0:00	6087	161.1479	10/16/2040 0:00	6133	161.2247	12/1/2040 0:00	6179	161.3009	1/16/2041 0:00	6225	161.3765
9/1/2040 0:00	6088	161.1496	10/17/2040 0:00	6134	161.2263	12/2/2040 0:00	6180	161.3025	1/17/2041 0:00	6226	161.3782
9/2/2040 0:00	6089	161.1512	10/18/2040 0:00	6135	161.228	12/3/2040 0:00	6181	161.3042	1/18/2041 0:00	6227	161.3798
9/3/2040 0:00	6090	161.1529	10/19/2040 0:00	6136	161.2296	12/4/2040 0:00	6182	161.3058	1/19/2041 0:00	6228	161.3814
9/4/2040 0:00	6091	161.1546	10/20/2040 0:00	6137	161.2313	12/5/2040 0:00	6183	161.3075	1/20/2041 0:00	6229	161.3831
9/5/2040 0:00	6092	161.1563	10/21/2040 0:00	6138	161.233	12/6/2040 0:00	6184	161.3091	1/21/2041 0:00	6230	161.3847
9/6/2040 0:00	6093	161.1579	10/22/2040 0:00	6139	161.2346	12/7/2040 0:00	6185	161.3108	1/22/2041 0:00	6231	161.3863
9/7/2040 0:00	6094	161.1596	10/23/2040 0:00	6140	161.2363	12/8/2040 0:00	6186	161.3124	1/23/2041 0:00	6232	161.388
9/8/2040 0:00	6095	161.1613	10/24/2040 0:00	6141	161.238	12/9/2040 0:00	6187	161.3141	1/24/2041 0:00	6233	161.3896
9/9/2040 0:00	6096	161.1629	10/25/2040 0:00	6142	161.2396	12/10/2040 0:00	6188	161.3157	1/25/2041 0:00	6234	161.3912
9/10/2040 0:00	6097	161.1646	10/26/2040 0:00	6143	161.2413	12/11/2040 0:00	6189	161.3174	1/26/2041 0:00	6235	161.3929
9/11/2040 0:00	6098	161.1663	10/27/2040 0:00	6144	161.2429	12/12/2040 0:00	6190	161.319	1/27/2041 0:00	6236	161.3945
9/12/2040 0:00	6099	161.168	10/28/2040 0:00	6145	161.2446	12/13/2040 0:00	6191	161.3207	1/28/2041 0:00	6237	161.3962
9/13/2040 0:00	6100	161.1696	10/29/2040 0:00	6146	161.2463	12/14/2040 0:00	6192	161.3223	1/29/2041 0:00	6238	161.3978
9/14/2040 0:00	6101	161.1713	10/30/2040 0:00	6147	161.2479	12/15/2040 0:00	6193	161.324	1/30/2041 0:00	6239	161.3994
9/15/2040 0:00	6102	161.173	10/31/2040 0:00	6148	161.2496	12/16/2040 0:00	6194	161.3256	1/31/2041 0:00	6240	161.4011
9/16/2040 0:00	6103	161.1746	11/1/2040 0:00	6149	161.2512	12/17/2040 0:00	6195	161.3272	2/1/2041 0:00	6241	161.4027
9/17/2040 0:00	6104	161.1763	11/2/2040 0:00	6150	161.2529	12/18/2040 0:00	6196	161.3289	2/2/2041 0:00	6242	161.4043
9/18/2040 0:00	6105	161.178	11/3/2040 0:00	6151	161.2545	12/19/2040 0:00	6197	161.3305	2/3/2041 0:00	6243	161.406

2/4/2041 0:00	6244	161.4076	3/22/2041 0:00	6290	161.4825	5/7/2041 0:00	6336	161.5568	6/22/2041 0:00	6382	161.6306
2/5/2041 0:00	6245	161.4092	3/23/2041 0:00	6291	161.4841	5/8/2041 0:00	6337	161.5584	6/23/2041 0:00	6383	161.6322
2/6/2041 0:00	6246	161.4109	3/24/2041 0:00	6292	161.4857	5/9/2041 0:00	6338	161.56	6/24/2041 0:00	6384	161.6337
2/7/2041 0:00	6247	161.4125	3/25/2041 0:00	6293	161.4873	5/10/2041 0:00	6339	161.5616	6/25/2041 0:00	6385	161.6353
2/8/2041 0:00	6248	161.4141	3/26/2041 0:00	6294	161.4889	5/11/2041 0:00	6340	161.5632	6/26/2041 0:00	6386	161.6369
2/9/2041 0:00	6249	161.4158	3/27/2041 0:00	6295	161.4906	5/12/2041 0:00	6341	161.5648	6/27/2041 0:00	6387	161.6385
2/10/2041 0:00	6250	161.4174	3/28/2041 0:00	6296	161.4922	5/13/2041 0:00	6342	161.5664	6/28/2041 0:00	6388	161.6401
2/11/2041 0:00	6251	161.419	3/29/2041 0:00	6297	161.4938	5/14/2041 0:00	6343	161.568	6/29/2041 0:00	6389	161.6417
2/12/2041 0:00	6252	161.4207	3/30/2041 0:00	6298	161.4954	5/15/2041 0:00	6344	161.5696	6/30/2041 0:00	6390	161.6433
2/13/2041 0:00	6253	161.4223	3/31/2041 0:00	6299	161.497	5/16/2041 0:00	6345	161.5713	7/1/2041 0:00	6391	161.6449
2/14/2041 0:00	6254	161.4239	4/1/2041 0:00	6300	161.4987	5/17/2041 0:00	6346	161.5729	7/2/2041 0:00	6392	161.6465
2/15/2041 0:00	6255	161.4255	4/2/2041 0:00	6301	161.5003	5/18/2041 0:00	6347	161.5745	7/3/2041 0:00	6393	161.6481
2/16/2041 0:00	6256	161.4272	4/3/2041 0:00	6302	161.5019	5/19/2041 0:00	6348	161.5761	7/4/2041 0:00	6394	161.6497
2/17/2041 0:00	6257	161.4288	4/4/2041 0:00	6303	161.5035	5/20/2041 0:00	6349	161.5777	7/5/2041 0:00	6395	161.6513
2/18/2041 0:00	6258	161.4304	4/5/2041 0:00	6304	161.5051	5/21/2041 0:00	6350	161.5793	7/6/2041 0:00	6396	161.6529
2/19/2041 0:00	6259	161.4321	4/6/2041 0:00	6305	161.5068	5/22/2041 0:00	6351	161.5809	7/7/2041 0:00	6397	161.6545
2/20/2041 0:00	6260	161.4337	4/7/2041 0:00	6306	161.5084	5/23/2041 0:00	6352	161.5825	7/8/2041 0:00	6398	161.6561
2/21/2041 0:00	6261	161.4353	4/8/2041 0:00	6307	161.51	5/24/2041 0:00	6353	161.5841	7/9/2041 0:00	6399	161.6577
2/22/2041 0:00	6262	161.437	4/9/2041 0:00	6308	161.5116	5/25/2041 0:00	6354	161.5857	7/10/2041 0:00	6400	161.6593
2/23/2041 0:00	6263	161.4386	4/10/2041 0:00	6309	161.5132	5/26/2041 0:00	6355	161.5873	7/11/2041 0:00	6401	161.6609
2/24/2041 0:00	6264	161.4402	4/11/2041 0:00	6310	161.5148	5/27/2041 0:00	6356	161.5889	7/12/2041 0:00	6402	161.6625
2/25/2041 0:00	6265	161.4418	4/12/2041 0:00	6311	161.5165	5/28/2041 0:00	6357	161.5905	7/13/2041 0:00	6403	161.6641
2/26/2041 0:00	6266	161.4435	4/13/2041 0:00	6312	161.5181	5/29/2041 0:00	6358	161.5921	7/14/2041 0:00	6404	161.6657
2/27/2041 0:00	6267	161.4451	4/14/2041 0:00	6313	161.5197	5/30/2041 0:00	6359	161.5937	7/15/2041 0:00	6405	161.6672
2/28/2041 0:00	6268	161.4467	4/15/2041 0:00	6314	161.5213	5/31/2041 0:00	6360	161.5953	7/16/2041 0:00	6406	161.6688
3/1/2041 0:00	6269	161.4484	4/16/2041 0:00	6315	161.5229	6/1/2041 0:00	6361	161.5969	7/17/2041 0:00	6407	161.6704
3/2/2041 0:00	6270	161.45	4/17/2041 0:00	6316	161.5245	6/2/2041 0:00	6362	161.5985	7/18/2041 0:00	6408	161.672
3/3/2041 0:00	6271	161.4516	4/18/2041 0:00	6317	161.5261	6/3/2041 0:00	6363	161.6001	7/19/2041 0:00	6409	161.6736
3/4/2041 0:00	6272	161.4532	4/19/2041 0:00	6318	161.5278	6/4/2041 0:00	6364	161.6017	7/20/2041 0:00	6410	161.6752
3/5/2041 0:00	6273	161.4549	4/20/2041 0:00	6319	161.5294	6/5/2041 0:00	6365	161.6033	7/21/2041 0:00	6411	161.6768
3/6/2041 0:00	6274	161.4565	4/21/2041 0:00	6320	161.531	6/6/2041 0:00	6366	161.605	7/22/2041 0:00	6412	161.6784
3/7/2041 0:00	6275	161.4581	4/22/2041 0:00	6321	161.5326	6/7/2041 0:00	6367	161.6066	7/23/2041 0:00	6413	161.68
3/8/2041 0:00	6276	161.4597	4/23/2041 0:00	6322	161.5342	6/8/2041 0:00	6368	161.6082	7/24/2041 0:00	6414	161.6816
3/9/2041 0:00	6277	161.4614	4/24/2041 0:00	6323	161.5358	6/9/2041 0:00	6369	161.6098	7/25/2041 0:00	6415	161.6832
3/10/2041 0:00	6278	161.463	4/25/2041 0:00	6324	161.5374	6/10/2041 0:00	6370	161.6114	7/26/2041 0:00	6416	161.6847
3/11/2041 0:00	6279	161.4646	4/26/2041 0:00	6325	161.5391	6/11/2041 0:00	6371	161.613	7/27/2041 0:00	6417	161.6863
3/12/2041 0:00	6280	161.4662	4/27/2041 0:00	6326	161.5407	6/12/2041 0:00	6372	161.6146	7/28/2041 0:00	6418	161.6879
3/13/2041 0:00	6281	161.4679	4/28/2041 0:00	6327	161.5423	6/13/2041 0:00	6373	161.6162	7/29/2041 0:00	6419	161.6895
3/14/2041 0:00	6282	161.4695	4/29/2041 0:00	6328	161.5439	6/14/2041 0:00	6374	161.6178	7/30/2041 0:00	6420	161.6911
3/15/2041 0:00	6283	161.4711	4/30/2041 0:00	6329	161.5455	6/15/2041 0:00	6375	161.6194	7/31/2041 0:00	6421	161.6927
3/16/2041 0:00	6284	161.4727	5/1/2041 0:00	6330	161.5471	6/16/2041 0:00	6376	161.621	8/1/2041 0:00	6422	161.6943
3/17/2041 0:00	6285	161.4743	5/2/2041 0:00	6331	161.5487	6/17/2041 0:00	6377	161.6226	8/2/2041 0:00	6423	161.6959
3/18/2041 0:00	6286	161.476	5/3/2041 0:00	6332	161.5503	6/18/2041 0:00	6378	161.6242	8/3/2041 0:00	6424	161.6975
3/19/2041 0:00	6287	161.4776	5/4/2041 0:00	6333	161.5519	6/19/2041 0:00	6379	161.6258	8/4/2041 0:00	6425	161.699
3/20/2041 0:00	6288	161.4792	5/5/2041 0:00	6334	161.5536	6/20/2041 0:00	6380	161.6274	8/5/2041 0:00	6426	161.7006
3/21/2041 0:00	6289	161.4808	5/6/2041 0:00	6335	161.5552	6/21/2041 0:00	6381	161.629	8/6/2041 0:00	6427	161.7022

8/7/2041 0:00	6428	161.7038	9/22/2041 0:00	6474	161.7765	11/7/2041 0:00	6520	161.8487	12/23/2041 0:00	6566	161.9204
8/8/2041 0:00	6429	161.7054	9/23/2041 0:00	6475	161.7781	11/8/2041 0:00	6521	161.8503	12/24/2041 0:00	6567	161.922
8/9/2041 0:00	6430	161.707	9/24/2041 0:00	6476	161.7797	11/9/2041 0:00	6522	161.8519	12/25/2041 0:00	6568	161.9236
8/10/2041 0:00	6431	161.7086	9/25/2041 0:00	6477	161.7813	11/10/2041 0:00	6523	161.8534	12/26/2041 0:00	6569	161.9251
8/11/2041 0:00	6432	161.7101	9/26/2041 0:00	6478	161.7828	11/11/2041 0:00	6524	161.855	12/27/2041 0:00	6570	161.9267
8/12/2041 0:00	6433	161.7117	9/27/2041 0:00	6479	161.7844	11/12/2041 0:00	6525	161.8566	12/28/2041 0:00	6571	161.9282
8/13/2041 0:00	6434	161.7133	9/28/2041 0:00	6480	161.786	11/13/2041 0:00	6526	161.8581	12/29/2041 0:00	6572	161.9298
8/14/2041 0:00	6435	161.7149	9/29/2041 0:00	6481	161.7876	11/14/2041 0:00	6527	161.8597	12/30/2041 0:00	6573	161.9313
8/15/2041 0:00	6436	161.7165	9/30/2041 0:00	6482	161.7891	11/15/2041 0:00	6528	161.8612	12/31/2041 0:00	6574	161.9329
8/16/2041 0:00	6437	161.7181	10/1/2041 0:00	6483	161.7907	11/16/2041 0:00	6529	161.8628	1/1/2042 0:00	6575	161.9344
8/17/2041 0:00	6438	161.7197	10/2/2041 0:00	6484	161.7923	11/17/2041 0:00	6530	161.8644	1/2/2042 0:00	6576	161.936
8/18/2041 0:00	6439	161.7212	10/3/2041 0:00	6485	161.7938	11/18/2041 0:00	6531	161.8659	1/3/2042 0:00	6577	161.9375
8/19/2041 0:00	6440	161.7228	10/4/2041 0:00	6486	161.7954	11/19/2041 0:00	6532	161.8675	1/4/2042 0:00	6578	161.9391
8/20/2041 0:00	6441	161.7244	10/5/2041 0:00	6487	161.797	11/20/2041 0:00	6533	161.8691	1/5/2042 0:00	6579	161.9406
8/21/2041 0:00	6442	161.726	10/6/2041 0:00	6488	161.7986	11/21/2041 0:00	6534	161.8706	1/6/2042 0:00	6580	161.9422
8/22/2041 0:00	6443	161.7276	10/7/2041 0:00	6489	161.8001	11/22/2041 0:00	6535	161.8722	1/7/2042 0:00	6581	161.9437
8/23/2041 0:00	6444	161.7292	10/8/2041 0:00	6490	161.8017	11/23/2041 0:00	6536	161.8737	1/8/2042 0:00	6582	161.9453
8/24/2041 0:00	6445	161.7307	10/9/2041 0:00	6491	161.8033	11/24/2041 0:00	6537	161.8753	1/9/2042 0:00	6583	161.9468
8/25/2041 0:00	6446	161.7323	10/10/2041 0:00	6492	161.8048	11/25/2041 0:00	6538	161.8769	1/10/2042 0:00	6584	161.9484
8/26/2041 0:00	6447	161.7339	10/11/2041 0:00	6493	161.8064	11/26/2041 0:00	6539	161.8784	1/11/2042 0:00	6585	161.9499
8/27/2041 0:00	6448	161.7355	10/12/2041 0:00	6494	161.808	11/27/2041 0:00	6540	161.88	1/12/2042 0:00	6586	161.9515
8/28/2041 0:00	6449	161.7371	10/13/2041 0:00	6495	161.8096	11/28/2041 0:00	6541	161.8815	1/13/2042 0:00	6587	161.953
8/29/2041 0:00	6450	161.7386	10/14/2041 0:00	6496	161.8111	11/29/2041 0:00	6542	161.8831	1/14/2042 0:00	6588	161.9546
8/30/2041 0:00	6451	161.7402	10/15/2041 0:00	6497	161.8127	11/30/2041 0:00	6543	161.8847	1/15/2042 0:00	6589	161.9561
8/31/2041 0:00	6452	161.7418	10/16/2041 0:00	6498	161.8143	12/1/2041 0:00	6544	161.8862	1/16/2042 0:00	6590	161.9577
9/1/2041 0:00	6453	161.7434	10/17/2041 0:00	6499	161.8158	12/2/2041 0:00	6545	161.8878	1/17/2042 0:00	6591	161.9592
9/2/2041 0:00	6454	161.745	10/18/2041 0:00	6500	161.8174	12/3/2041 0:00	6546	161.8893	1/18/2042 0:00	6592	161.9608
9/3/2041 0:00	6455	161.7466	10/19/2041 0:00	6501	161.819	12/4/2041 0:00	6547	161.8909	1/19/2042 0:00	6593	161.9623
9/4/2041 0:00	6456	161.7481	10/20/2041 0:00	6502	161.8205	12/5/2041 0:00	6548	161.8924	1/20/2042 0:00	6594	161.9638
9/5/2041 0:00	6457	161.7497	10/21/2041 0:00	6503	161.8221	12/6/2041 0:00	6549	161.894	1/21/2042 0:00	6595	161.9654
9/6/2041 0:00	6458	161.7513	10/22/2041 0:00	6504	161.8237	12/7/2041 0:00	6550	161.8956	1/22/2042 0:00	6596	161.9669
9/7/2041 0:00	6459	161.7529	10/23/2041 0:00	6505	161.8252	12/8/2041 0:00	6551	161.8971	1/23/2042 0:00	6597	161.9685
9/8/2041 0:00	6460	161.7544	10/24/2041 0:00	6506	161.8268	12/9/2041 0:00	6552	161.8987	1/24/2042 0:00	6598	161.97
9/9/2041 0:00	6461	161.756	10/25/2041 0:00	6507	161.8284	12/10/2041 0:00	6553	161.9002	1/25/2042 0:00	6599	161.9716
9/10/2041 0:00	6462	161.7576	10/26/2041 0:00	6508	161.83	12/11/2041 0:00	6554	161.9018	1/26/2042 0:00	6600	161.9731
9/11/2041 0:00	6463	161.7592	10/27/2041 0:00	6509	161.8315	12/12/2041 0:00	6555	161.9033	1/27/2042 0:00	6601	161.9747
9/12/2041 0:00	6464	161.7608	10/28/2041 0:00	6510	161.8331	12/13/2041 0:00	6556	161.9049	1/28/2042 0:00	6602	161.9762
9/13/2041 0:00	6465	161.7623	10/29/2041 0:00	6511	161.8347	12/14/2041 0:00	6557	161.9065	1/29/2042 0:00	6603	161.9778
9/14/2041 0:00	6466	161.7639	10/30/2041 0:00	6512	161.8362	12/15/2041 0:00	6558	161.908	1/30/2042 0:00	6604	161.9793
9/15/2041 0:00	6467	161.7655	10/31/2041 0:00	6513	161.8378	12/16/2041 0:00	6559	161.9096	1/31/2042 0:00	6605	161.9808
9/16/2041 0:00	6468	161.7671	11/1/2041 0:00	6514	161.8394	12/17/2041 0:00	6560	161.9111	2/1/2042 0:00	6606	161.9824
9/17/2041 0:00	6469	161.7686	11/2/2041 0:00	6515	161.8409	12/18/2041 0:00	6561	161.9127	2/2/2042 0:00	6607	161.9839
9/18/2041 0:00	6470	161.7702	11/3/2041 0:00	6516	161.8425	12/19/2041 0:00	6562	161.9142	2/3/2042 0:00	6608	161.9855
9/19/2041 0:00	6471	161.7718	11/4/2041 0:00	6517	161.844	12/20/2041 0:00	6563	161.9158	2/4/2042 0:00	6609	161.987
9/20/2041 0:00	6472	161.7734	11/5/2041 0:00	6518	161.8456	12/21/2041 0:00	6564	161.9173	2/5/2042 0:00	6610	161.9886
9/21/2041 0:00	6473	161.775	11/6/2041 0:00	6519	161.8472	12/22/2041 0:00	6565	161.9189	2/6/2042 0:00	6611	161.9901

2/7/2042 0:00	6612	161.9917	3/25/2042 0:00	6658	162.0624	5/10/2042 0:00	6704	162.1326	6/25/2042 0:00	6750	162.2023
2/8/2042 0:00	6613	161.9932	3/26/2042 0:00	6659	162.0639	5/11/2042 0:00	6705	162.1341	6/26/2042 0:00	6751	162.2038
2/9/2042 0:00	6614	161.9947	3/27/2042 0:00	6660	162.0654	5/12/2042 0:00	6706	162.1356	6/27/2042 0:00	6752	162.2054
2/10/2042 0:00	6615	161.9963	3/28/2042 0:00	6661	162.067	5/13/2042 0:00	6707	162.1371	6/28/2042 0:00	6753	162.2069
2/11/2042 0:00	6616	161.9978	3/29/2042 0:00	6662	162.0685	5/14/2042 0:00	6708	162.1387	6/29/2042 0:00	6754	162.2084
2/12/2042 0:00	6617	161.9994	3/30/2042 0:00	6663	162.07	5/15/2042 0:00	6709	162.1402	6/30/2042 0:00	6755	162.2099
2/13/2042 0:00	6618	162.0009	3/31/2042 0:00	6664	162.0715	5/16/2042 0:00	6710	162.1417	7/1/2042 0:00	6756	162.2114
2/14/2042 0:00	6619	162.0024	4/1/2042 0:00	6665	162.0731	5/17/2042 0:00	6711	162.1432	7/2/2042 0:00	6757	162.2129
2/15/2042 0:00	6620	162.004	4/2/2042 0:00	6666	162.0746	5/18/2042 0:00	6712	162.1448	7/3/2042 0:00	6758	162.2144
2/16/2042 0:00	6621	162.0055	4/3/2042 0:00	6667	162.0761	5/19/2042 0:00	6713	162.1463	7/4/2042 0:00	6759	162.2159
2/17/2042 0:00	6622	162.0071	4/4/2042 0:00	6668	162.0777	5/20/2042 0:00	6714	162.1478	7/5/2042 0:00	6760	162.2174
2/18/2042 0:00	6623	162.0086	4/5/2042 0:00	6669	162.0792	5/21/2042 0:00	6715	162.1493	7/6/2042 0:00	6761	162.2189
2/19/2042 0:00	6624	162.0101	4/6/2042 0:00	6670	162.0807	5/22/2042 0:00	6716	162.1508	7/7/2042 0:00	6762	162.2204
2/20/2042 0:00	6625	162.0117	4/7/2042 0:00	6671	162.0823	5/23/2042 0:00	6717	162.1523	7/8/2042 0:00	6763	162.222
2/21/2042 0:00	6626	162.0132	4/8/2042 0:00	6672	162.0838	5/24/2042 0:00	6718	162.1539	7/9/2042 0:00	6764	162.2235
2/22/2042 0:00	6627	162.0148	4/9/2042 0:00	6673	162.0853	5/25/2042 0:00	6719	162.1554	7/10/2042 0:00	6765	162.225
2/23/2042 0:00	6628	162.0163	4/10/2042 0:00	6674	162.0868	5/26/2042 0:00	6720	162.1569	7/11/2042 0:00	6766	162.2265
2/24/2042 0:00	6629	162.0178	4/11/2042 0:00	6675	162.0884	5/27/2042 0:00	6721	162.1584	7/12/2042 0:00	6767	162.228
2/25/2042 0:00	6630	162.0194	4/12/2042 0:00	6676	162.0899	5/28/2042 0:00	6722	162.1599	7/13/2042 0:00	6768	162.2295
2/26/2042 0:00	6631	162.0209	4/13/2042 0:00	6677	162.0914	5/29/2042 0:00	6723	162.1615	7/14/2042 0:00	6769	162.231
2/27/2042 0:00	6632	162.0225	4/14/2042 0:00	6678	162.093	5/30/2042 0:00	6724	162.163	7/15/2042 0:00	6770	162.2325
2/28/2042 0:00	6633	162.024	4/15/2042 0:00	6679	162.0945	5/31/2042 0:00	6725	162.1645	7/16/2042 0:00	6771	162.234
3/1/2042 0:00	6634	162.0255	4/16/2042 0:00	6680	162.096	6/1/2042 0:00	6726	162.166	7/17/2042 0:00	6772	162.2355
3/2/2042 0:00	6635	162.0271	4/17/2042 0:00	6681	162.0975	6/2/2042 0:00	6727	162.1675	7/18/2042 0:00	6773	162.237
3/3/2042 0:00	6636	162.0286	4/18/2042 0:00	6682	162.0991	6/3/2042 0:00	6728	162.169	7/19/2042 0:00	6774	162.2385
3/4/2042 0:00	6637	162.0301	4/19/2042 0:00	6683	162.1006	6/4/2042 0:00	6729	162.1706	7/20/2042 0:00	6775	162.24
3/5/2042 0:00	6638	162.0317	4/20/2042 0:00	6684	162.1021	6/5/2042 0:00	6730	162.1721	7/21/2042 0:00	6776	162.2415
3/6/2042 0:00	6639	162.0332	4/21/2042 0:00	6685	162.1036	6/6/2042 0:00	6731	162.1736	7/22/2042 0:00	6777	162.243
3/7/2042 0:00	6640	162.0348	4/22/2042 0:00	6686	162.1052	6/7/2042 0:00	6732	162.1751	7/23/2042 0:00	6778	162.2446
3/8/2042 0:00	6641	162.0363	4/23/2042 0:00	6687	162.1067	6/8/2042 0:00	6733	162.1766	7/24/2042 0:00	6779	162.2461
3/9/2042 0:00	6642	162.0378	4/24/2042 0:00	6688	162.1082	6/9/2042 0:00	6734	162.1781	7/25/2042 0:00	6780	162.2476
3/10/2042 0:00	6643	162.0394	4/25/2042 0:00	6689	162.1097	6/10/2042 0:00	6735	162.1796	7/26/2042 0:00	6781	162.2491
3/11/2042 0:00	6644	162.0409	4/26/2042 0:00	6690	162.1113	6/11/2042 0:00	6736	162.1812	7/27/2042 0:00	6782	162.2506
3/12/2042 0:00	6645	162.0424	4/27/2042 0:00	6691	162.1128	6/12/2042 0:00	6737	162.1827	7/28/2042 0:00	6783	162.2521
3/13/2042 0:00	6646	162.044	4/28/2042 0:00	6692	162.1143	6/13/2042 0:00	6738	162.1842	7/29/2042 0:00	6784	162.2536
3/14/2042 0:00	6647	162.0455	4/29/2042 0:00	6693	162.1158	6/14/2042 0:00	6739	162.1857	7/30/2042 0:00	6785	162.2551
3/15/2042 0:00	6648	162.047	4/30/2042 0:00	6694	162.1174	6/15/2042 0:00	6740	162.1872	7/31/2042 0:00	6786	162.2566
3/16/2042 0:00	6649	162.0486	5/1/2042 0:00	6695	162.1189	6/16/2042 0:00	6741	162.1887	8/1/2042 0:00	6787	162.2581
3/17/2042 0:00	6650	162.0501	5/2/2042 0:00	6696	162.1204	6/17/2042 0:00	6742	162.1902	8/2/2042 0:00	6788	162.2596
3/18/2042 0:00	6651	162.0516	5/3/2042 0:00	6697	162.1219	6/18/2042 0:00	6743	162.1917	8/3/2042 0:00	6789	162.2611
3/19/2042 0:00	6652	162.0532	5/4/2042 0:00	6698	162.1235	6/19/2042 0:00	6744	162.1933	8/4/2042 0:00	6790	162.2626
3/20/2042 0:00	6653	162.0547	5/5/2042 0:00	6699	162.125	6/20/2042 0:00	6745	162.1948	8/5/2042 0:00	6791	162.2641
3/21/2042 0:00	6654	162.0562	5/6/2042 0:00	6700	162.1265	6/21/2042 0:00	6746	162.1963	8/6/2042 0:00	6792	162.2656
3/22/2042 0:00	6655	162.0578	5/7/2042 0:00	6701	162.128	6/22/2042 0:00	6747	162.1978	8/7/2042 0:00	6793	162.2671
3/23/2042 0:00	6656	162.0593	5/8/2042 0:00	6702	162.1295	6/23/2042 0:00	6748	162.1993	8/8/2042 0:00	6794	162.2686
3/24/2042 0:00	6657	162.0608	5/9/2042 0:00	6703	162.1311	6/24/2042 0:00	6749	162.2008	8/9/2042 0:00	6795	162.2701

8/10/2042 0:00	6796	162.2716	9/25/2042 0:00	6842	162.3404	11/10/2042 0:00	6888	162.4088	12/26/2042 0:00	6934	162.4766
8/11/2042 0:00	6797	162.2731	9/26/2042 0:00	6843	162.3419	11/11/2042 0:00	6889	162.4102	12/27/2042 0:00	6935	162.4781
8/12/2042 0:00	6798	162.2746	9/27/2042 0:00	6844	162.3434	11/12/2042 0:00	6890	162.4117	12/28/2042 0:00	6936	162.4796
8/13/2042 0:00	6799	162.2761	9/28/2042 0:00	6845	162.3449	11/13/2042 0:00	6891	162.4132	12/29/2042 0:00	6937	162.4811
8/14/2042 0:00	6800	162.2776	9/29/2042 0:00	6846	162.3464	11/14/2042 0:00	6892	162.4147	12/30/2042 0:00	6938	162.4825
8/15/2042 0:00	6801	162.2791	9/30/2042 0:00	6847	162.3479	11/15/2042 0:00	6893	162.4162	12/31/2042 0:00	6939	162.484
8/16/2042 0:00	6802	162.2806	10/1/2042 0:00	6848	162.3493	11/16/2042 0:00	6894	162.4176	1/1/2043 0:00	6940	162.4855
8/17/2042 0:00	6803	162.2821	10/2/2042 0:00	6849	162.3508	11/17/2042 0:00	6895	162.4191	1/2/2043 0:00	6941	162.4869
8/18/2042 0:00	6804	162.2836	10/3/2042 0:00	6850	162.3523	11/18/2042 0:00	6896	162.4206	1/3/2043 0:00	6942	162.4884
8/19/2042 0:00	6805	162.2851	10/4/2042 0:00	6851	162.3538	11/19/2042 0:00	6897	162.4221	1/4/2043 0:00	6943	162.4899
8/20/2042 0:00	6806	162.2866	10/5/2042 0:00	6852	162.3553	11/20/2042 0:00	6898	162.4235	1/5/2043 0:00	6944	162.4913
8/21/2042 0:00	6807	162.2881	10/6/2042 0:00	6853	162.3568	11/21/2042 0:00	6899	162.425	1/6/2043 0:00	6945	162.4928
8/22/2042 0:00	6808	162.2896	10/7/2042 0:00	6854	162.3583	11/22/2042 0:00	6900	162.4265	1/7/2043 0:00	6946	162.4943
8/23/2042 0:00	6809	162.2911	10/8/2042 0:00	6855	162.3598	11/23/2042 0:00	6901	162.428	1/8/2043 0:00	6947	162.4957
8/24/2042 0:00	6810	162.2926	10/9/2042 0:00	6856	162.3613	11/24/2042 0:00	6902	162.4295	1/9/2043 0:00	6948	162.4972
8/25/2042 0:00	6811	162.2941	10/10/2042 0:00	6857	162.3627	11/25/2042 0:00	6903	162.4309	1/10/2043 0:00	6949	162.4987
8/26/2042 0:00	6812	162.2956	10/11/2042 0:00	6858	162.3642	11/26/2042 0:00	6904	162.4324	1/11/2043 0:00	6950	162.5001
8/27/2042 0:00	6813	162.2971	10/12/2042 0:00	6859	162.3657	11/27/2042 0:00	6905	162.4339	1/12/2043 0:00	6951	162.5016
8/28/2042 0:00	6814	162.2986	10/13/2042 0:00	6860	162.3672	11/28/2042 0:00	6906	162.4354	1/13/2043 0:00	6952	162.5031
8/29/2042 0:00	6815	162.3001	10/14/2042 0:00	6861	162.3687	11/29/2042 0:00	6907	162.4368	1/14/2043 0:00	6953	162.5045
8/30/2042 0:00	6816	162.3016	10/15/2042 0:00	6862	162.3702	11/30/2042 0:00	6908	162.4383	1/15/2043 0:00	6954	162.506
8/31/2042 0:00	6817	162.3031	10/16/2042 0:00	6863	162.3717	12/1/2042 0:00	6909	162.4398	1/16/2043 0:00	6955	162.5075
9/1/2042 0:00	6818	162.3046	10/17/2042 0:00	6864	162.3732	12/2/2042 0:00	6910	162.4413	1/17/2043 0:00	6956	162.5089
9/2/2042 0:00	6819	162.3061	10/18/2042 0:00	6865	162.3746	12/3/2042 0:00	6911	162.4428	1/18/2043 0:00	6957	162.5104
9/3/2042 0:00	6820	162.3076	10/19/2042 0:00	6866	162.3761	12/4/2042 0:00	6912	162.4442	1/19/2043 0:00	6958	162.5119
9/4/2042 0:00	6821	162.3091	10/20/2042 0:00	6867	162.3776	12/5/2042 0:00	6913	162.4457	1/20/2043 0:00	6959	162.5133
9/5/2042 0:00	6822	162.3105	10/21/2042 0:00	6868	162.3791	12/6/2042 0:00	6914	162.4472	1/21/2043 0:00	6960	162.5148
9/6/2042 0:00	6823	162.312	10/22/2042 0:00	6869	162.3806	12/7/2042 0:00	6915	162.4487	1/22/2043 0:00	6961	162.5163
9/7/2042 0:00	6824	162.3135	10/23/2042 0:00	6870	162.3821	12/8/2042 0:00	6916	162.4501	1/23/2043 0:00	6962	162.5177
9/8/2042 0:00	6825	162.315	10/24/2042 0:00	6871	162.3835	12/9/2042 0:00	6917	162.4516	1/24/2043 0:00	6963	162.5192
9/9/2042 0:00	6826	162.3165	10/25/2042 0:00	6872	162.385	12/10/2042 0:00	6918	162.4531	1/25/2043 0:00	6964	162.5207
9/10/2042 0:00	6827	162.318	10/26/2042 0:00	6873	162.3865	12/11/2042 0:00	6919	162.4546	1/26/2043 0:00	6965	162.5221
9/11/2042 0:00	6828	162.3195	10/27/2042 0:00	6874	162.388	12/12/2042 0:00	6920	162.456	1/27/2043 0:00	6966	162.5236
9/12/2042 0:00	6829	162.321	10/28/2042 0:00	6875	162.3895	12/13/2042 0:00	6921	162.4575	1/28/2043 0:00	6967	162.5251
9/13/2042 0:00	6830	162.3225	10/29/2042 0:00	6876	162.391	12/14/2042 0:00	6922	162.459	1/29/2043 0:00	6968	162.5265
9/14/2042 0:00	6831	162.324	10/30/2042 0:00	6877	162.3924	12/15/2042 0:00	6923	162.4604	1/30/2043 0:00	6969	162.528
9/15/2042 0:00	6832	162.3255	10/31/2042 0:00	6878	162.3939	12/16/2042 0:00	6924	162.4619	1/31/2043 0:00	6970	162.5295
9/16/2042 0:00	6833	162.327	11/1/2042 0:00	6879	162.3954	12/17/2042 0:00	6925	162.4634	2/1/2043 0:00	6971	162.5309
9/17/2042 0:00	6834	162.3285	11/2/2042 0:00	6880	162.3969	12/18/2042 0:00	6926	162.4649	2/2/2043 0:00	6972	162.5324
9/18/2042 0:00	6835	162.33	11/3/2042 0:00	6881	162.3984	12/19/2042 0:00	6927	162.4663	2/3/2043 0:00	6973	162.5338
9/19/2042 0:00	6836	162.3315	11/4/2042 0:00	6882	162.3999	12/20/2042 0:00	6928	162.4678	2/4/2043 0:00	6974	162.5353
9/20/2042 0:00	6837	162.333	11/5/2042 0:00	6883	162.4013	12/21/2042 0:00	6929	162.4693	2/5/2043 0:00	6975	162.5368
9/21/2042 0:00	6838	162.3344	11/6/2042 0:00	6884	162.4028	12/22/2042 0:00	6930	162.4708	2/6/2043 0:00	6976	162.5382
9/22/2042 0:00	6839	162.3359	11/7/2042 0:00	6885	162.4043	12/23/2042 0:00	6931	162.4722	2/7/2043 0:00	6977	162.5397
9/23/2042 0:00	6840	162.3374	11/8/2042 0:00	6886	162.4058	12/24/2042 0:00	6932	162.4737	2/8/2043 0:00	6978	162.5412
9/24/2042 0:00	6841	162.3389	11/9/2042 0:00	6887	162.4073	12/25/2042 0:00	6933	162.4752	2/9/2043 0:00	6979	162.5426

2/10/2043 0:00	6980	162.5441	3/28/2043 0:00	7026	162.6111	5/13/2043 0:00	7072	162.6776	6/28/2043 0:00	7118	162.7438
2/11/2043 0:00	6981	162.5455	3/29/2043 0:00	7027	162.6125	5/14/2043 0:00	7073	162.6791	6/29/2043 0:00	7119	162.7452
2/12/2043 0:00	6982	162.547	3/30/2043 0:00	7028	162.614	5/15/2043 0:00	7074	162.6805	6/30/2043 0:00	7120	162.7466
2/13/2043 0:00	6983	162.5485	3/31/2043 0:00	7029	162.6154	5/16/2043 0:00	7075	162.682	7/1/2043 0:00	7121	162.7481
2/14/2043 0:00	6984	162.5499	4/1/2043 0:00	7030	162.6169	5/17/2043 0:00	7076	162.6834	7/2/2043 0:00	7122	162.7495
2/15/2043 0:00	6985	162.5514	4/2/2043 0:00	7031	162.6183	5/18/2043 0:00	7077	162.6848	7/3/2043 0:00	7123	162.7509
2/16/2043 0:00	6986	162.5528	4/3/2043 0:00	7032	162.6198	5/19/2043 0:00	7078	162.6863	7/4/2043 0:00	7124	162.7524
2/17/2043 0:00	6987	162.5543	4/4/2043 0:00	7033	162.6212	5/20/2043 0:00	7079	162.6877	7/5/2043 0:00	7125	162.7538
2/18/2043 0:00	6988	162.5558	4/5/2043 0:00	7034	162.6227	5/21/2043 0:00	7080	162.6892	7/6/2043 0:00	7126	162.7552
2/19/2043 0:00	6989	162.5572	4/6/2043 0:00	7035	162.6241	5/22/2043 0:00	7081	162.6906	7/7/2043 0:00	7127	162.7567
2/20/2043 0:00	6990	162.5587	4/7/2043 0:00	7036	162.6256	5/23/2043 0:00	7082	162.6921	7/8/2043 0:00	7128	162.7581
2/21/2043 0:00	6991	162.5601	4/8/2043 0:00	7037	162.627	5/24/2043 0:00	7083	162.6935	7/9/2043 0:00	7129	162.7595
2/22/2043 0:00	6992	162.5616	4/9/2043 0:00	7038	162.6285	5/25/2043 0:00	7084	162.6949	7/10/2043 0:00	7130	162.7609
2/23/2043 0:00	6993	162.5631	4/10/2043 0:00	7039	162.6299	5/26/2043 0:00	7085	162.6964	7/11/2043 0:00	7131	162.7624
2/24/2043 0:00	6994	162.5645	4/11/2043 0:00	7040	162.6314	5/27/2043 0:00	7086	162.6978	7/12/2043 0:00	7132	162.7638
2/25/2043 0:00	6995	162.566	4/12/2043 0:00	7041	162.6328	5/28/2043 0:00	7087	162.6992	7/13/2043 0:00	7133	162.7652
2/26/2043 0:00	6996	162.5674	4/13/2043 0:00	7042	162.6343	5/29/2043 0:00	7088	162.7007	7/14/2043 0:00	7134	162.7667
2/27/2043 0:00	6997	162.5689	4/14/2043 0:00	7043	162.6357	5/30/2043 0:00	7089	162.7021	7/15/2043 0:00	7135	162.7681
2/28/2043 0:00	6998	162.5703	4/15/2043 0:00	7044	162.6372	5/31/2043 0:00	7090	162.7036	7/16/2043 0:00	7136	162.7695
3/1/2043 0:00	6999	162.5718	4/16/2043 0:00	7045	162.6386	6/1/2043 0:00	7091	162.705	7/17/2043 0:00	7137	162.771
3/2/2043 0:00	7000	162.5733	4/17/2043 0:00	7046	162.6401	6/2/2043 0:00	7092	162.7064	7/18/2043 0:00	7138	162.7724
3/3/2043 0:00	7001	162.5747	4/18/2043 0:00	7047	162.6415	6/3/2043 0:00	7093	162.7079	7/19/2043 0:00	7139	162.7738
3/4/2043 0:00	7002	162.5762	4/19/2043 0:00	7048	162.643	6/4/2043 0:00	7094	162.7093	7/20/2043 0:00	7140	162.7752
3/5/2043 0:00	7003	162.5776	4/20/2043 0:00	7049	162.6444	6/5/2043 0:00	7095	162.7108	7/21/2043 0:00	7141	162.7767
3/6/2043 0:00	7004	162.5791	4/21/2043 0:00	7050	162.6459	6/6/2043 0:00	7096	162.7122	7/22/2043 0:00	7142	162.7781
3/7/2043 0:00	7005	162.5805	4/22/2043 0:00	7051	162.6473	6/7/2043 0:00	7097	162.7136	7/23/2043 0:00	7143	162.7795
3/8/2043 0:00	7006	162.582	4/23/2043 0:00	7052	162.6488	6/8/2043 0:00	7098	162.7151	7/24/2043 0:00	7144	162.781
3/9/2043 0:00	7007	162.5835	4/24/2043 0:00	7053	162.6502	6/9/2043 0:00	7099	162.7165	7/25/2043 0:00	7145	162.7824
3/10/2043 0:00	7008	162.5849	4/25/2043 0:00	7054	162.6516	6/10/2043 0:00	7100	162.7179	7/26/2043 0:00	7146	162.7838
3/11/2043 0:00	7009	162.5864	4/26/2043 0:00	7055	162.6531	6/11/2043 0:00	7101	162.7194	7/27/2043 0:00	7147	162.7852
3/12/2043 0:00	7010	162.5878	4/27/2043 0:00	7056	162.6545	6/12/2043 0:00	7102	162.7208	7/28/2043 0:00	7148	162.7867
3/13/2043 0:00	7011	162.5893	4/28/2043 0:00	7057	162.656	6/13/2043 0:00	7103	162.7223	7/29/2043 0:00	7149	162.7881
3/14/2043 0:00	7012	162.5907	4/29/2043 0:00	7058	162.6574	6/14/2043 0:00	7104	162.7237	7/30/2043 0:00	7150	162.7895
3/15/2043 0:00	7013	162.5922	4/30/2043 0:00	7059	162.6589	6/15/2043 0:00	7105	162.7251	7/31/2043 0:00	7151	162.7909
3/16/2043 0:00	7014	162.5936	5/1/2043 0:00	7060	162.6603	6/16/2043 0:00	7106	162.7266	8/1/2043 0:00	7152	162.7924
3/17/2043 0:00	7015	162.5951	5/2/2043 0:00	7061	162.6618	6/17/2043 0:00	7107	162.728	8/2/2043 0:00	7153	162.7938
3/18/2043 0:00	7016	162.5966	5/3/2043 0:00	7062	162.6632	6/18/2043 0:00	7108	162.7294	8/3/2043 0:00	7154	162.7952
3/19/2043 0:00	7017	162.598	5/4/2043 0:00	7063	162.6646	6/19/2043 0:00	7109	162.7309	8/4/2043 0:00	7155	162.7966
3/20/2043 0:00	7018	162.5995	5/5/2043 0:00	7064	162.6661	6/20/2043 0:00	7110	162.7323	8/5/2043 0:00	7156	162.7981
3/21/2043 0:00	7019	162.6009	5/6/2043 0:00	7065	162.6675	6/21/2043 0:00	7111	162.7337	8/6/2043 0:00	7157	162.7995
3/22/2043 0:00	7020	162.6024	5/7/2043 0:00	7066	162.669	6/22/2043 0:00	7112	162.7352	8/7/2043 0:00	7158	162.8009
3/23/2043 0:00	7021	162.6038	5/8/2043 0:00	7067	162.6704	6/23/2043 0:00	7113	162.7366	8/8/2043 0:00	7159	162.8023
3/24/2043 0:00	7022	162.6053	5/9/2043 0:00	7068	162.6719	6/24/2043 0:00	7114	162.738	8/9/2043 0:00	7160	162.8038
3/25/2043 0:00	7023	162.6067	5/10/2043 0:00	7069	162.6733	6/25/2043 0:00	7115	162.7395	8/10/2043 0:00	7161	162.8052
3/26/2043 0:00	7024	162.6082	5/11/2043 0:00	7070	162.6748	6/26/2043 0:00	7116	162.7409	8/11/2043 0:00	7162	162.8066
3/27/2043 0:00	7025	162.6096	5/12/2043 0:00	7071	162.6762	6/27/2043 0:00	7117	162.7423	8/12/2043 0:00	7163	162.808

8/13/2043 0:00	7164	162.8095	9/28/2043 0:00	7210	162.8748	11/13/2043 0:00	7256	162.9396	12/29/2043 0:00	7302	163.0041
8/14/2043 0:00	7165	162.8109	9/29/2043 0:00	7211	162.8762	11/14/2043 0:00	7257	162.941	12/30/2043 0:00	7303	163.0055
8/15/2043 0:00	7166	162.8123	9/30/2043 0:00	7212	162.8776	11/15/2043 0:00	7258	162.9424	12/31/2043 0:00	7304	163.0069
8/16/2043 0:00	7167	162.8137	10/1/2043 0:00	7213	162.879	11/16/2043 0:00	7259	162.9438	1/1/2044 0:00	7305	163.0083
8/17/2043 0:00	7168	162.8152	10/2/2043 0:00	7214	162.8804	11/17/2043 0:00	7260	162.9452	1/2/2044 0:00	7306	163.0097
8/18/2043 0:00	7169	162.8166	10/3/2043 0:00	7215	162.8818	11/18/2043 0:00	7261	162.9466	1/3/2044 0:00	7307	163.0111
8/19/2043 0:00	7170	162.818	10/4/2043 0:00	7216	162.8832	11/19/2043 0:00	7262	162.9481	1/4/2044 0:00	7308	163.0125
8/20/2043 0:00	7171	162.8194	10/5/2043 0:00	7217	162.8847	11/20/2043 0:00	7263	162.9495	1/5/2044 0:00	7309	163.0139
8/21/2043 0:00	7172	162.8209	10/6/2043 0:00	7218	162.8861	11/21/2043 0:00	7264	162.9509	1/6/2044 0:00	7310	163.0152
8/22/2043 0:00	7173	162.8223	10/7/2043 0:00	7219	162.8875	11/22/2043 0:00	7265	162.9523	1/7/2044 0:00	7311	163.0166
8/23/2043 0:00	7174	162.8237	10/8/2043 0:00	7220	162.8889	11/23/2043 0:00	7266	162.9537	1/8/2044 0:00	7312	163.018
8/24/2043 0:00	7175	162.8251	10/9/2043 0:00	7221	162.8903	11/24/2043 0:00	7267	162.9551	1/9/2044 0:00	7313	163.0194
8/25/2043 0:00	7176	162.8265	10/10/2043 0:00	7222	162.8917	11/25/2043 0:00	7268	162.9565	1/10/2044 0:00	7314	163.0208
8/26/2043 0:00	7177	162.828	10/11/2043 0:00	7223	162.8931	11/26/2043 0:00	7269	162.9579	1/11/2044 0:00	7315	163.0222
8/27/2043 0:00	7178	162.8294	10/12/2043 0:00	7224	162.8945	11/27/2043 0:00	7270	162.9593	1/12/2044 0:00	7316	163.0236
8/28/2043 0:00	7179	162.8308	10/13/2043 0:00	7225	162.896	11/28/2043 0:00	7271	162.9607	1/13/2044 0:00	7317	163.025
8/29/2043 0:00	7180	162.8322	10/14/2043 0:00	7226	162.8974	11/29/2043 0:00	7272	162.9621	1/14/2044 0:00	7318	163.0264
8/30/2043 0:00	7181	162.8336	10/15/2043 0:00	7227	162.8988	11/30/2043 0:00	7273	162.9635	1/15/2044 0:00	7319	163.0278
8/31/2043 0:00	7182	162.8351	10/16/2043 0:00	7228	162.9002	12/1/2043 0:00	7274	162.9649	1/16/2044 0:00	7320	163.0292
9/1/2043 0:00	7183	162.8365	10/17/2043 0:00	7229	162.9016	12/2/2043 0:00	7275	162.9663	1/17/2044 0:00	7321	163.0306
9/2/2043 0:00	7184	162.8379	10/18/2043 0:00	7230	162.903	12/3/2043 0:00	7276	162.9677	1/18/2044 0:00	7322	163.032
9/3/2043 0:00	7185	162.8393	10/19/2043 0:00	7231	162.9044	12/4/2043 0:00	7277	162.9691	1/19/2044 0:00	7323	163.0334
9/4/2043 0:00	7186	162.8407	10/20/2043 0:00	7232	162.9058	12/5/2043 0:00	7278	162.9705	1/20/2044 0:00	7324	163.0348
9/5/2043 0:00	7187	162.8422	10/21/2043 0:00	7233	162.9072	12/6/2043 0:00	7279	162.9719	1/21/2044 0:00	7325	163.0362
9/6/2043 0:00	7188	162.8436	10/22/2043 0:00	7234	162.9086	12/7/2043 0:00	7280	162.9733	1/22/2044 0:00	7326	163.0375
9/7/2043 0:00	7189	162.845	10/23/2043 0:00	7235	162.9101	12/8/2043 0:00	7281	162.9747	1/23/2044 0:00	7327	163.0389
9/8/2043 0:00	7190	162.8464	10/24/2043 0:00	7236	162.9115	12/9/2043 0:00	7282	162.9761	1/24/2044 0:00	7328	163.0403
9/9/2043 0:00	7191	162.8478	10/25/2043 0:00	7237	162.9129	12/10/2043 0:00	7283	162.9775	1/25/2044 0:00	7329	163.0417
9/10/2043 0:00	7192	162.8493	10/26/2043 0:00	7238	162.9143	12/11/2043 0:00	7284	162.9789	1/26/2044 0:00	7330	163.0431
9/11/2043 0:00	7193	162.8507	10/27/2043 0:00	7239	162.9157	12/12/2043 0:00	7285	162.9803	1/27/2044 0:00	7331	163.0445
9/12/2043 0:00	7194	162.8521	10/28/2043 0:00	7240	162.9171	12/13/2043 0:00	7286	162.9817	1/28/2044 0:00	7332	163.0459
9/13/2043 0:00	7195	162.8535	10/29/2043 0:00	7241	162.9185	12/14/2043 0:00	7287	162.9831	1/29/2044 0:00	7333	163.0473
9/14/2043 0:00	7196	162.8549	10/30/2043 0:00	7242	162.9199	12/15/2043 0:00	7288	162.9845	1/30/2044 0:00	7334	163.0487
9/15/2043 0:00	7197	162.8563	10/31/2043 0:00	7243	162.9213	12/16/2043 0:00	7289	162.9859	1/31/2044 0:00	7335	163.0501
9/16/2043 0:00	7198	162.8578	11/1/2043 0:00	7244	162.9227	12/17/2043 0:00	7290	162.9873	2/1/2044 0:00	7336	163.0515
9/17/2043 0:00	7199	162.8592	11/2/2043 0:00	7245	162.9241	12/18/2043 0:00	7291	162.9887	2/2/2044 0:00	7337	163.0529
9/18/2043 0:00	7200	162.8606	11/3/2043 0:00	7246	162.9256	12/19/2043 0:00	7292	162.9901	2/3/2044 0:00	7338	163.0542
9/19/2043 0:00	7201	162.862	11/4/2043 0:00	7247	162.927	12/20/2043 0:00	7293	162.9915	2/4/2044 0:00	7339	163.0556
9/20/2043 0:00	7202	162.8634	11/5/2043 0:00	7248	162.9284	12/21/2043 0:00	7294	162.9929	2/5/2044 0:00	7340	163.057
9/21/2043 0:00	7203	162.8648	11/6/2043 0:00	7249	162.9298	12/22/2043 0:00	7295	162.9943	2/6/2044 0:00	7341	163.0584
9/22/2043 0:00	7204	162.8663	11/7/2043 0:00	7250	162.9312	12/23/2043 0:00	7296	162.9957	2/7/2044 0:00	7342	163.0598
9/23/2043 0:00	7205	162.8677	11/8/2043 0:00	7251	162.9326	12/24/2043 0:00	7297	162.9971	2/8/2044 0:00	7343	163.0612
9/24/2043 0:00	7206	162.8691	11/9/2043 0:00	7252	162.934	12/25/2043 0:00	7298	162.9985	2/9/2044 0:00	7344	163.0626
9/25/2043 0:00	7207	162.8705	11/10/2043 0:00	7253	162.9354	12/26/2043 0:00	7299	162.9999	2/10/2044 0:00	7345	163.064
9/26/2043 0:00	7208	162.8719	11/11/2043 0:00	7254	162.9368	12/27/2043 0:00	7300	163.0013	2/11/2044 0:00	7346	163.0654
9/27/2043 0:00	7209	162.8733	11/12/2043 0:00	7255	162.9382	12/28/2043 0:00	7301	163.0027	2/12/2044 0:00	7347	163.0667

2/13/2044 0:00	7348	163.0681	3/30/2044 0:00	7394	163.1318	5/15/2044 0:00	7440	163.195	6/30/2044 0:00	7486	163.2579
2/14/2044 0:00	7349	163.0695	3/31/2044 0:00	7395	163.1332	5/16/2044 0:00	7441	163.1964	7/1/2044 0:00	7487	163.2593
2/15/2044 0:00	7350	163.0709	4/1/2044 0:00	7396	163.1345	5/17/2044 0:00	7442	163.1978	7/2/2044 0:00	7488	163.2606
2/16/2044 0:00	7351	163.0723	4/2/2044 0:00	7397	163.1359	5/18/2044 0:00	7443	163.1992	7/3/2044 0:00	7489	163.262
2/17/2044 0:00	7352	163.0737	4/3/2044 0:00	7398	163.1373	5/19/2044 0:00	7444	163.2005	7/4/2044 0:00	7490	163.2634
2/18/2044 0:00	7353	163.0751	4/4/2044 0:00	7399	163.1387	5/20/2044 0:00	7445	163.2019	7/5/2044 0:00	7491	163.2647
2/19/2044 0:00	7354	163.0765	4/5/2044 0:00	7400	163.1401	5/21/2044 0:00	7446	163.2033	7/6/2044 0:00	7492	163.2661
2/20/2044 0:00	7355	163.0778	4/6/2044 0:00	7401	163.1414	5/22/2044 0:00	7447	163.2046	7/7/2044 0:00	7493	163.2675
2/21/2044 0:00	7356	163.0792	4/7/2044 0:00	7402	163.1428	5/23/2044 0:00	7448	163.206	7/8/2044 0:00	7494	163.2688
2/22/2044 0:00	7357	163.0806	4/8/2044 0:00	7403	163.1442	5/24/2044 0:00	7449	163.2074	7/9/2044 0:00	7495	163.2702
2/23/2044 0:00	7358	163.082	4/9/2044 0:00	7404	163.1456	5/25/2044 0:00	7450	163.2087	7/10/2044 0:00	7496	163.2715
2/24/2044 0:00	7359	163.0834	4/10/2044 0:00	7405	163.147	5/26/2044 0:00	7451	163.2101	7/11/2044 0:00	7497	163.2729
2/25/2044 0:00	7360	163.0848	4/11/2044 0:00	7406	163.1483	5/27/2044 0:00	7452	163.2115	7/12/2044 0:00	7498	163.2743
2/26/2044 0:00	7361	163.0862	4/12/2044 0:00	7407	163.1497	5/28/2044 0:00	7453	163.2129	7/13/2044 0:00	7499	163.2756
2/27/2044 0:00	7362	163.0875	4/13/2044 0:00	7408	163.1511	5/29/2044 0:00	7454	163.2142	7/14/2044 0:00	7500	163.277
2/28/2044 0:00	7363	163.0889	4/14/2044 0:00	7409	163.1525	5/30/2044 0:00	7455	163.2156	7/15/2044 0:00	7501	163.2783
2/29/2044 0:00	7364	163.0903	4/15/2044 0:00	7410	163.1538	5/31/2044 0:00	7456	163.217	7/16/2044 0:00	7502	163.2797
3/1/2044 0:00	7365	163.0917	4/16/2044 0:00	7411	163.1552	6/1/2044 0:00	7457	163.2183	7/17/2044 0:00	7503	163.2811
3/2/2044 0:00	7366	163.0931	4/17/2044 0:00	7412	163.1566	6/2/2044 0:00	7458	163.2197	7/18/2044 0:00	7504	163.2824
3/3/2044 0:00	7367	163.0945	4/18/2044 0:00	7413	163.158	6/3/2044 0:00	7459	163.2211	7/19/2044 0:00	7505	163.2838
3/4/2044 0:00	7368	163.0959	4/19/2044 0:00	7414	163.1593	6/4/2044 0:00	7460	163.2224	7/20/2044 0:00	7506	163.2851
3/5/2044 0:00	7369	163.0972	4/20/2044 0:00	7415	163.1607	6/5/2044 0:00	7461	163.2238	7/21/2044 0:00	7507	163.2865
3/6/2044 0:00	7370	163.0986	4/21/2044 0:00	7416	163.1621	6/6/2044 0:00	7462	163.2252	7/22/2044 0:00	7508	163.2879
3/7/2044 0:00	7371	163.1	4/22/2044 0:00	7417	163.1635	6/7/2044 0:00	7463	163.2265	7/23/2044 0:00	7509	163.2892
3/8/2044 0:00	7372	163.1014	4/23/2044 0:00	7418	163.1648	6/8/2044 0:00	7464	163.2279	7/24/2044 0:00	7510	163.2906
3/9/2044 0:00	7373	163.1028	4/24/2044 0:00	7419	163.1662	6/9/2044 0:00	7465	163.2293	7/25/2044 0:00	7511	163.2919
3/10/2044 0:00	7374	163.1042	4/25/2044 0:00	7420	163.1676	6/10/2044 0:00	7466	163.2306	7/26/2044 0:00	7512	163.2933
3/11/2044 0:00	7375	163.1055	4/26/2044 0:00	7421	163.169	6/11/2044 0:00	7467	163.232	7/27/2044 0:00	7513	163.2946
3/12/2044 0:00	7376	163.1069	4/27/2044 0:00	7422	163.1703	6/12/2044 0:00	7468	163.2334	7/28/2044 0:00	7514	163.296
3/13/2044 0:00	7377	163.1083	4/28/2044 0:00	7423	163.1717	6/13/2044 0:00	7469	163.2347	7/29/2044 0:00	7515	163.2974
3/14/2044 0:00	7378	163.1097	4/29/2044 0:00	7424	163.1731	6/14/2044 0:00	7470	163.2361	7/30/2044 0:00	7516	163.2987
3/15/2044 0:00	7379	163.1111	4/30/2044 0:00	7425	163.1745	6/15/2044 0:00	7471	163.2375	7/31/2044 0:00	7517	163.3001
3/16/2044 0:00	7380	163.1125	5/1/2044 0:00	7426	163.1758	6/16/2044 0:00	7472	163.2388	8/1/2044 0:00	7518	163.3014
3/17/2044 0:00	7381	163.1138	5/2/2044 0:00	7427	163.1772	6/17/2044 0:00	7473	163.2402	8/2/2044 0:00	7519	163.3028
3/18/2044 0:00	7382	163.1152	5/3/2044 0:00	7428	163.1786	6/18/2044 0:00	7474	163.2416	8/3/2044 0:00	7520	163.3041
3/19/2044 0:00	7383	163.1166	5/4/2044 0:00	7429	163.18	6/19/2044 0:00	7475	163.2429	8/4/2044 0:00	7521	163.3055
3/20/2044 0:00	7384	163.118	5/5/2044 0:00	7430	163.1813	6/20/2044 0:00	7476	163.2443	8/5/2044 0:00	7522	163.3069
3/21/2044 0:00	7385	163.1194	5/6/2044 0:00	7431	163.1827	6/21/2044 0:00	7477	163.2456	8/6/2044 0:00	7523	163.3082
3/22/2044 0:00	7386	163.1207	5/7/2044 0:00	7432	163.1841	6/22/2044 0:00	7478	163.247	8/7/2044 0:00	7524	163.3096
3/23/2044 0:00	7387	163.1221	5/8/2044 0:00	7433	163.1854	6/23/2044 0:00	7479	163.2484	8/8/2044 0:00	7525	163.3109
3/24/2044 0:00	7388	163.1235	5/9/2044 0:00	7434	163.1868	6/24/2044 0:00	7480	163.2497	8/9/2044 0:00	7526	163.3123
3/25/2044 0:00	7389	163.1249	5/10/2044 0:00	7435	163.1882	6/25/2044 0:00	7481	163.2511	8/10/2044 0:00	7527	163.3136
3/26/2044 0:00	7390	163.1263	5/11/2044 0:00	7436	163.1896	6/26/2044 0:00	7482	163.2525	8/11/2044 0:00	7528	163.315
3/27/2044 0:00	7391	163.1276	5/12/2044 0:00	7437	163.1909	6/27/2044 0:00	7483	163.2538	8/12/2044 0:00	7529	163.3163
3/28/2044 0:00	7392	163.129	5/13/2044 0:00	7438	163.1923	6/28/2044 0:00	7484	163.2552	8/13/2044 0:00	7530	163.3177
3/29/2044 0:00	7393	163.1304	5/14/2044 0:00	7439	163.1937	6/29/2044 0:00	7485	163.2566	8/14/2044 0:00	7531	163.319

8/15/2044 0:00	7532	163.3204	9/30/2044 0:00	7578	163.3825	11/15/2044 0:00	7624	163.4442	12/31/2044 0:00	7670	163.5056
8/16/2044 0:00	7533	163.3218	10/1/2044 0:00	7579	163.3839	11/16/2044 0:00	7625	163.4456	1/1/2045 0:00	7671	163.5069
8/17/2044 0:00	7534	163.3231	10/2/2044 0:00	7580	163.3852	11/17/2044 0:00	7626	163.4469	1/2/2045 0:00	7672	163.5083
8/18/2044 0:00	7535	163.3245	10/3/2044 0:00	7581	163.3865	11/18/2044 0:00	7627	163.4483	1/3/2045 0:00	7673	163.5096
8/19/2044 0:00	7536	163.3258	10/4/2044 0:00	7582	163.3879	11/19/2044 0:00	7628	163.4496	1/4/2045 0:00	7674	163.5109
8/20/2044 0:00	7537	163.3272	10/5/2044 0:00	7583	163.3892	11/20/2044 0:00	7629	163.4509	1/5/2045 0:00	7675	163.5122
8/21/2044 0:00	7538	163.3285	10/6/2044 0:00	7584	163.3906	11/21/2044 0:00	7630	163.4523	1/6/2045 0:00	7676	163.5136
8/22/2044 0:00	7539	163.3299	10/7/2044 0:00	7585	163.3919	11/22/2044 0:00	7631	163.4536	1/7/2045 0:00	7677	163.5149
8/23/2044 0:00	7540	163.3312	10/8/2044 0:00	7586	163.3933	11/23/2044 0:00	7632	163.4549	1/8/2045 0:00	7678	163.5162
8/24/2044 0:00	7541	163.3326	10/9/2044 0:00	7587	163.3946	11/24/2044 0:00	7633	163.4563	1/9/2045 0:00	7679	163.5176
8/25/2044 0:00	7542	163.3339	10/10/2044 0:00	7588	163.396	11/25/2044 0:00	7634	163.4576	1/10/2045 0:00	7680	163.5189
8/26/2044 0:00	7543	163.3353	10/11/2044 0:00	7589	163.3973	11/26/2044 0:00	7635	163.4589	1/11/2045 0:00	7681	163.5202
8/27/2044 0:00	7544	163.3366	10/12/2044 0:00	7590	163.3986	11/27/2044 0:00	7636	163.4603	1/12/2045 0:00	7682	163.5215
8/28/2044 0:00	7545	163.338	10/13/2044 0:00	7591	163.4	11/28/2044 0:00	7637	163.4616	1/13/2045 0:00	7683	163.5229
8/29/2044 0:00	7546	163.3393	10/14/2044 0:00	7592	163.4013	11/29/2044 0:00	7638	163.463	1/14/2045 0:00	7684	163.5242
8/30/2044 0:00	7547	163.3407	10/15/2044 0:00	7593	163.4027	11/30/2044 0:00	7639	163.4643	1/15/2045 0:00	7685	163.5255
8/31/2044 0:00	7548	163.342	10/16/2044 0:00	7594	163.404	12/1/2044 0:00	7640	163.4656	1/16/2045 0:00	7686	163.5269
9/1/2044 0:00	7549	163.3434	10/17/2044 0:00	7595	163.4054	12/2/2044 0:00	7641	163.467	1/17/2045 0:00	7687	163.5282
9/2/2044 0:00	7550	163.3448	10/18/2044 0:00	7596	163.4067	12/3/2044 0:00	7642	163.4683	1/18/2045 0:00	7688	163.5295
9/3/2044 0:00	7551	163.3461	10/19/2044 0:00	7597	163.4081	12/4/2044 0:00	7643	163.4696	1/19/2045 0:00	7689	163.5308
9/4/2044 0:00	7552	163.3475	10/20/2044 0:00	7598	163.4094	12/5/2044 0:00	7644	163.471	1/20/2045 0:00	7690	163.5322
9/5/2044 0:00	7553	163.3488	10/21/2044 0:00	7599	163.4107	12/6/2044 0:00	7645	163.4723	1/21/2045 0:00	7691	163.5335
9/6/2044 0:00	7554	163.3502	10/22/2044 0:00	7600	163.4121	12/7/2044 0:00	7646	163.4736	1/22/2045 0:00	7692	163.5348
9/7/2044 0:00	7555	163.3515	10/23/2044 0:00	7601	163.4134	12/8/2044 0:00	7647	163.475	1/23/2045 0:00	7693	163.5361
9/8/2044 0:00	7556	163.3529	10/24/2044 0:00	7602	163.4148	12/9/2044 0:00	7648	163.4763	1/24/2045 0:00	7694	163.5375
9/9/2044 0:00	7557	163.3542	10/25/2044 0:00	7603	163.4161	12/10/2044 0:00	7649	163.4776	1/25/2045 0:00	7695	163.5388
9/10/2044 0:00	7558	163.3556	10/26/2044 0:00	7604	163.4174	12/11/2044 0:00	7650	163.479	1/26/2045 0:00	7696	163.5401
9/11/2044 0:00	7559	163.3569	10/27/2044 0:00	7605	163.4188	12/12/2044 0:00	7651	163.4803	1/27/2045 0:00	7697	163.5414
9/12/2044 0:00	7560	163.3583	10/28/2044 0:00	7606	163.4201	12/13/2044 0:00	7652	163.4816	1/28/2045 0:00	7698	163.5428
9/13/2044 0:00	7561	163.3596	10/29/2044 0:00	7607	163.4215	12/14/2044 0:00	7653	163.483	1/29/2045 0:00	7699	163.5441
9/14/2044 0:00	7562	163.3609	10/30/2044 0:00	7608	163.4228	12/15/2044 0:00	7654	163.4843	1/30/2045 0:00	7700	163.5454
9/15/2044 0:00	7563	163.3623	10/31/2044 0:00	7609	163.4241	12/16/2044 0:00	7655	163.4856	1/31/2045 0:00	7701	163.5467
9/16/2044 0:00	7564	163.3636	11/1/2044 0:00	7610	163.4255	12/17/2044 0:00	7656	163.487	2/1/2045 0:00	7702	163.5481
9/17/2044 0:00	7565	163.365	11/2/2044 0:00	7611	163.4268	12/18/2044 0:00	7657	163.4883	2/2/2045 0:00	7703	163.5494
9/18/2044 0:00	7566	163.3663	11/3/2044 0:00	7612	163.4282	12/19/2044 0:00	7658	163.4896	2/3/2045 0:00	7704	163.5507
9/19/2044 0:00	7567	163.3677	11/4/2044 0:00	7613	163.4295	12/20/2044 0:00	7659	163.491	2/4/2045 0:00	7705	163.552
9/20/2044 0:00	7568	163.369	11/5/2044 0:00	7614	163.4308	12/21/2044 0:00	7660	163.4923	2/5/2045 0:00	7706	163.5534
9/21/2044 0:00	7569	163.3704	11/6/2044 0:00	7615	163.4322	12/22/2044 0:00	7661	163.4936	2/6/2045 0:00	7707	163.5547
9/22/2044 0:00	7570	163.3717	11/7/2044 0:00	7616	163.4335	12/23/2044 0:00	7662	163.495	2/7/2045 0:00	7708	163.556
9/23/2044 0:00	7571	163.3731	11/8/2044 0:00	7617	163.4349	12/24/2044 0:00	7663	163.4963	2/8/2045 0:00	7709	163.5573
9/24/2044 0:00	7572	163.3744	11/9/2044 0:00	7618	163.4362	12/25/2044 0:00	7664	163.4976	2/9/2045 0:00	7710	163.5587
9/25/2044 0:00	7573	163.3758	11/10/2044 0:00	7619	163.4375	12/26/2044 0:00	7665	163.4989	2/10/2045 0:00	7711	163.56
9/26/2044 0:00	7574	163.3771	11/11/2044 0:00	7620	163.4389	12/27/2044 0:00	7666	163.5003	2/11/2045 0:00	7712	163.5613
9/27/2044 0:00	7575	163.3785	11/12/2044 0:00	7621	163.4402	12/28/2044 0:00	7667	163.5016	2/12/2045 0:00	7713	163.5626
9/28/2044 0:00	7576	163.3798	11/13/2044 0:00	7622	163.4416	12/29/2044 0:00	7668	163.5029	2/13/2045 0:00	7714	163.5639
9/29/2044 0:00	7577	163.3812	11/14/2044 0:00	7623	163.4429	12/30/2044 0:00	7669	163.5043	2/14/2045 0:00	7715	163.5653

2/15/2045 0:00	7716	163.5666	4/2/2045 0:00	7762	163.6272	5/18/2045 0:00	7808	163.6875	7/3/2045 0:00	7854	163.7474
2/16/2045 0:00	7717	163.5679	4/3/2045 0:00	7763	163.6285	5/19/2045 0:00	7809	163.6888	7/4/2045 0:00	7855	163.7487
2/17/2045 0:00	7718	163.5692	4/4/2045 0:00	7764	163.6298	5/20/2045 0:00	7810	163.6901	7/5/2045 0:00	7856	163.75
2/18/2045 0:00	7719	163.5706	4/5/2045 0:00	7765	163.6312	5/21/2045 0:00	7811	163.6914	7/6/2045 0:00	7857	163.7513
2/19/2045 0:00	7720	163.5719	4/6/2045 0:00	7766	163.6325	5/22/2045 0:00	7812	163.6927	7/7/2045 0:00	7858	163.7526
2/20/2045 0:00	7721	163.5732	4/7/2045 0:00	7767	163.6338	5/23/2045 0:00	7813	163.694	7/8/2045 0:00	7859	163.7539
2/21/2045 0:00	7722	163.5745	4/8/2045 0:00	7768	163.6351	5/24/2045 0:00	7814	163.6953	7/9/2045 0:00	7860	163.7552
2/22/2045 0:00	7723	163.5758	4/9/2045 0:00	7769	163.6364	5/25/2045 0:00	7815	163.6966	7/10/2045 0:00	7861	163.7565
2/23/2045 0:00	7724	163.5772	4/10/2045 0:00	7770	163.6377	5/26/2045 0:00	7816	163.6979	7/11/2045 0:00	7862	163.7578
2/24/2045 0:00	7725	163.5785	4/11/2045 0:00	7771	163.639	5/27/2045 0:00	7817	163.6992	7/12/2045 0:00	7863	163.7591
2/25/2045 0:00	7726	163.5798	4/12/2045 0:00	7772	163.6403	5/28/2045 0:00	7818	163.7005	7/13/2045 0:00	7864	163.7604
2/26/2045 0:00	7727	163.5811	4/13/2045 0:00	7773	163.6417	5/29/2045 0:00	7819	163.7018	7/14/2045 0:00	7865	163.7617
2/27/2045 0:00	7728	163.5824	4/14/2045 0:00	7774	163.643	5/30/2045 0:00	7820	163.7032	7/15/2045 0:00	7866	163.763
2/28/2045 0:00	7729	163.5838	4/15/2045 0:00	7775	163.6443	5/31/2045 0:00	7821	163.7045	7/16/2045 0:00	7867	163.7643
3/1/2045 0:00	7730	163.5851	4/16/2045 0:00	7776	163.6456	6/1/2045 0:00	7822	163.7058	7/17/2045 0:00	7868	163.7656
3/2/2045 0:00	7731	163.5864	4/17/2045 0:00	7777	163.6469	6/2/2045 0:00	7823	163.7071	7/18/2045 0:00	7869	163.7669
3/3/2045 0:00	7732	163.5877	4/18/2045 0:00	7778	163.6482	6/3/2045 0:00	7824	163.7084	7/19/2045 0:00	7870	163.7682
3/4/2045 0:00	7733	163.589	4/19/2045 0:00	7779	163.6495	6/4/2045 0:00	7825	163.7097	7/20/2045 0:00	7871	163.7695
3/5/2045 0:00	7734	163.5904	4/20/2045 0:00	7780	163.6508	6/5/2045 0:00	7826	163.711	7/21/2045 0:00	7872	163.7708
3/6/2045 0:00	7735	163.5917	4/21/2045 0:00	7781	163.6522	6/6/2045 0:00	7827	163.7123	7/22/2045 0:00	7873	163.772
3/7/2045 0:00	7736	163.593	4/22/2045 0:00	7782	163.6535	6/7/2045 0:00	7828	163.7136	7/23/2045 0:00	7874	163.7733
3/8/2045 0:00	7737	163.5943	4/23/2045 0:00	7783	163.6548	6/8/2045 0:00	7829	163.7149	7/24/2045 0:00	7875	163.7746
3/9/2045 0:00	7738	163.5956	4/24/2045 0:00	7784	163.6561	6/9/2045 0:00	7830	163.7162	7/25/2045 0:00	7876	163.7759
3/10/2045 0:00	7739	163.5969	4/25/2045 0:00	7785	163.6574	6/10/2045 0:00	7831	163.7175	7/26/2045 0:00	7877	163.7772
3/11/2045 0:00	7740	163.5983	4/26/2045 0:00	7786	163.6587	6/11/2045 0:00	7832	163.7188	7/27/2045 0:00	7878	163.7785
3/12/2045 0:00	7741	163.5996	4/27/2045 0:00	7787	163.66	6/12/2045 0:00	7833	163.7201	7/28/2045 0:00	7879	163.7798
3/13/2045 0:00	7742	163.6009	4/28/2045 0:00	7788	163.6613	6/13/2045 0:00	7834	163.7214	7/29/2045 0:00	7880	163.7811
3/14/2045 0:00	7743	163.6022	4/29/2045 0:00	7789	163.6626	6/14/2045 0:00	7835	163.7227	7/30/2045 0:00	7881	163.7824
3/15/2045 0:00	7744	163.6035	4/30/2045 0:00	7790	163.6639	6/15/2045 0:00	7836	163.724	7/31/2045 0:00	7882	163.7837
3/16/2045 0:00	7745	163.6049	5/1/2045 0:00	7791	163.6653	6/16/2045 0:00	7837	163.7253	8/1/2045 0:00	7883	163.785
3/17/2045 0:00	7746	163.6062	5/2/2045 0:00	7792	163.6666	6/17/2045 0:00	7838	163.7266	8/2/2045 0:00	7884	163.7863
3/18/2045 0:00	7747	163.6075	5/3/2045 0:00	7793	163.6679	6/18/2045 0:00	7839	163.7279	8/3/2045 0:00	7885	163.7876
3/19/2045 0:00	7748	163.6088	5/4/2045 0:00	7794	163.6692	6/19/2045 0:00	7840	163.7292	8/4/2045 0:00	7886	163.7889
3/20/2045 0:00	7749	163.6101	5/5/2045 0:00	7795	163.6705	6/20/2045 0:00	7841	163.7305	8/5/2045 0:00	7887	163.7902
3/21/2045 0:00	7750	163.6114	5/6/2045 0:00	7796	163.6718	6/21/2045 0:00	7842	163.7318	8/6/2045 0:00	7888	163.7915
3/22/2045 0:00	7751	163.6128	5/7/2045 0:00	7797	163.6731	6/22/2045 0:00	7843	163.7331	8/7/2045 0:00	7889	163.7928
3/23/2045 0:00	7752	163.6141	5/8/2045 0:00	7798	163.6744	6/23/2045 0:00	7844	163.7344	8/8/2045 0:00	7890	163.7941
3/24/2045 0:00	7753	163.6154	5/9/2045 0:00	7799	163.6757	6/24/2045 0:00	7845	163.7357	8/9/2045 0:00	7891	163.7953
3/25/2045 0:00	7754	163.6167	5/10/2045 0:00	7800	163.677	6/25/2045 0:00	7846	163.737	8/10/2045 0:00	7892	163.7966
3/26/2045 0:00	7755	163.618	5/11/2045 0:00	7801	163.6783	6/26/2045 0:00	7847	163.7383	8/11/2045 0:00	7893	163.7979
3/27/2045 0:00	7756	163.6193	5/12/2045 0:00	7802	163.6796	6/27/2045 0:00	7848	163.7396	8/12/2045 0:00	7894	163.7992
3/28/2045 0:00	7757	163.6206	5/13/2045 0:00	7803	163.681	6/28/2045 0:00	7849	163.7409	8/13/2045 0:00	7895	163.8005
3/29/2045 0:00	7758	163.622	5/14/2045 0:00	7804	163.6823	6/29/2045 0:00	7850	163.7422	8/14/2045 0:00	7896	163.8018
3/30/2045 0:00	7759	163.6233	5/15/2045 0:00	7805	163.6836	6/30/2045 0:00	7851	163.7435	8/15/2045 0:00	7897	163.8031
3/31/2045 0:00	7760	163.6246	5/16/2045 0:00	7806	163.6849	7/1/2045 0:00	7852	163.7448	8/16/2045 0:00	7898	163.8044
4/1/2045 0:00	7761	163.6259	5/17/2045 0:00	7807	163.6862	7/2/2045 0:00	7853	163.7461	8/17/2045 0:00	7899	163.8057

8/18/2045 0:00	7900	163.807	10/3/2045 0:00	7946	163.8662	11/18/2045 0:00	7992	163.9251	1/3/2046 0:00	8038	163.9836
8/19/2045 0:00	7901	163.8083	10/4/2045 0:00	7947	163.8675	11/19/2045 0:00	7993	163.9263	1/4/2046 0:00	8039	163.9849
8/20/2045 0:00	7902	163.8096	10/5/2045 0:00	7948	163.8688	11/20/2045 0:00	7994	163.9276	1/5/2046 0:00	8040	163.9862
8/21/2045 0:00	7903	163.8108	10/6/2045 0:00	7949	163.87	11/21/2045 0:00	7995	163.9289	1/6/2046 0:00	8041	163.9874
8/22/2045 0:00	7904	163.8121	10/7/2045 0:00	7950	163.8713	11/22/2045 0:00	7996	163.9302	1/7/2046 0:00	8042	163.9887
8/23/2045 0:00	7905	163.8134	10/8/2045 0:00	7951	163.8726	11/23/2045 0:00	7997	163.9315	1/8/2046 0:00	8043	163.99
8/24/2045 0:00	7906	163.8147	10/9/2045 0:00	7952	163.8739	11/24/2045 0:00	7998	163.9327	1/9/2046 0:00	8044	163.9912
8/25/2045 0:00	7907	163.816	10/10/2045 0:00	7953	163.8752	11/25/2045 0:00	7999	163.934	1/10/2046 0:00	8045	163.9925
8/26/2045 0:00	7908	163.8173	10/11/2045 0:00	7954	163.8765	11/26/2045 0:00	8000	163.9353	1/11/2046 0:00	8046	163.9938
8/27/2045 0:00	7909	163.8186	10/12/2045 0:00	7955	163.8777	11/27/2045 0:00	8001	163.9366	1/12/2046 0:00	8047	163.995
8/28/2045 0:00	7910	163.8199	10/13/2045 0:00	7956	163.879	11/28/2045 0:00	8002	163.9378	1/13/2046 0:00	8048	163.9963
8/29/2045 0:00	7911	163.8212	10/14/2045 0:00	7957	163.8803	11/29/2045 0:00	8003	163.9391	1/14/2046 0:00	8049	163.9976
8/30/2045 0:00	7912	163.8225	10/15/2045 0:00	7958	163.8816	11/30/2045 0:00	8004	163.9404	1/15/2046 0:00	8050	163.9988
8/31/2045 0:00	7913	163.8237	10/16/2045 0:00	7959	163.8829	12/1/2045 0:00	8005	163.9417	1/16/2046 0:00	8051	164.0001
9/1/2045 0:00	7914	163.825	10/17/2045 0:00	7960	163.8841	12/2/2045 0:00	8006	163.9429	1/17/2046 0:00	8052	164.0014
9/2/2045 0:00	7915	163.8263	10/18/2045 0:00	7961	163.8854	12/3/2045 0:00	8007	163.9442	1/18/2046 0:00	8053	164.0026
9/3/2045 0:00	7916	163.8276	10/19/2045 0:00	7962	163.8867	12/4/2045 0:00	8008	163.9455	1/19/2046 0:00	8054	164.0039
9/4/2045 0:00	7917	163.8289	10/20/2045 0:00	7963	163.888	12/5/2045 0:00	8009	163.9467	1/20/2046 0:00	8055	164.0052
9/5/2045 0:00	7918	163.8302	10/21/2045 0:00	7964	163.8893	12/6/2045 0:00	8010	163.948	1/21/2046 0:00	8056	164.0064
9/6/2045 0:00	7919	163.8315	10/22/2045 0:00	7965	163.8906	12/7/2045 0:00	8011	163.9493	1/22/2046 0:00	8057	164.0077
9/7/2045 0:00	7920	163.8328	10/23/2045 0:00	7966	163.8918	12/8/2045 0:00	8012	163.9506	1/23/2046 0:00	8058	164.009
9/8/2045 0:00	7921	163.834	10/24/2045 0:00	7967	163.8931	12/9/2045 0:00	8013	163.9518	1/24/2046 0:00	8059	164.0102
9/9/2045 0:00	7922	163.8353	10/25/2045 0:00	7968	163.8944	12/10/2045 0:00	8014	163.9531	1/25/2046 0:00	8060	164.0115
9/10/2045 0:00	7923	163.8366	10/26/2045 0:00	7969	163.8957	12/11/2045 0:00	8015	163.9544	1/26/2046 0:00	8061	164.0128
9/11/2045 0:00	7924	163.8379	10/27/2045 0:00	7970	163.897	12/12/2045 0:00	8016	163.9557	1/27/2046 0:00	8062	164.014
9/12/2045 0:00	7925	163.8392	10/28/2045 0:00	7971	163.8982	12/13/2045 0:00	8017	163.9569	1/28/2046 0:00	8063	164.0153
9/13/2045 0:00	7926	163.8405	10/29/2045 0:00	7972	163.8995	12/14/2045 0:00	8018	163.9582	1/29/2046 0:00	8064	164.0166
9/14/2045 0:00	7927	163.8418	10/30/2045 0:00	7973	163.9008	12/15/2045 0:00	8019	163.9595	1/30/2046 0:00	8065	164.0178
9/15/2045 0:00	7928	163.8431	10/31/2045 0:00	7974	163.9021	12/16/2045 0:00	8020	163.9607	1/31/2046 0:00	8066	164.0191
9/16/2045 0:00	7929	163.8443	11/1/2045 0:00	7975	163.9034	12/17/2045 0:00	8021	163.962	2/1/2046 0:00	8067	164.0203
9/17/2045 0:00	7930	163.8456	11/2/2045 0:00	7976	163.9046	12/18/2045 0:00	8022	163.9633	2/2/2046 0:00	8068	164.0216
9/18/2045 0:00	7931	163.8469	11/3/2045 0:00	7977	163.9059	12/19/2045 0:00	8023	163.9646	2/3/2046 0:00	8069	164.0229
9/19/2045 0:00	7932	163.8482	11/4/2045 0:00	7978	163.9072	12/20/2045 0:00	8024	163.9658	2/4/2046 0:00	8070	164.0241
9/20/2045 0:00	7933	163.8495	11/5/2045 0:00	7979	163.9085	12/21/2045 0:00	8025	163.9671	2/5/2046 0:00	8071	164.0254
9/21/2045 0:00	7934	163.8508	11/6/2045 0:00	7980	163.9097	12/22/2045 0:00	8026	163.9684	2/6/2046 0:00	8072	164.0267
9/22/2045 0:00	7935	163.8521	11/7/2045 0:00	7981	163.911	12/23/2045 0:00	8027	163.9696	2/7/2046 0:00	8073	164.0279
9/23/2045 0:00	7936	163.8533	11/8/2045 0:00	7982	163.9123	12/24/2045 0:00	8028	163.9709	2/8/2046 0:00	8074	164.0292
9/24/2045 0:00	7937	163.8546	11/9/2045 0:00	7983	163.9136	12/25/2045 0:00	8029	163.9722	2/9/2046 0:00	8075	164.0305
9/25/2045 0:00	7938	163.8559	11/10/2045 0:00	7984	163.9149	12/26/2045 0:00	8030	163.9735	2/10/2046 0:00	8076	164.0317
9/26/2045 0:00	7939	163.8572	11/11/2045 0:00	7985	163.9161	12/27/2045 0:00	8031	163.9747	2/11/2046 0:00	8077	164.033
9/27/2045 0:00	7940	163.8585	11/12/2045 0:00	7986	163.9174	12/28/2045 0:00	8032	163.976	2/12/2046 0:00	8078	164.0342
9/28/2045 0:00	7941	163.8598	11/13/2045 0:00	7987	163.9187	12/29/2045 0:00	8033	163.9773	2/13/2046 0:00	8079	164.0355
9/29/2045 0:00	7942	163.8611	11/14/2045 0:00	7988	163.92	12/30/2045 0:00	8034	163.9785	2/14/2046 0:00	8080	164.0368
9/30/2045 0:00	7943	163.8623	11/15/2045 0:00	7989	163.9212	12/31/2045 0:00	8035	163.9798	2/15/2046 0:00	8081	164.038
10/1/2045 0:00	7944	163.8636	11/16/2045 0:00	7990	163.9225	1/1/2046 0:00	8036	163.9811	2/16/2046 0:00	8082	164.0393
10/2/2045 0:00	7945	163.8649	11/17/2045 0:00	7991	163.9238	1/2/2046 0:00	8037	163.9823	2/17/2046 0:00	8083	164.0406

2/18/2046 0:00	8084	164.0418	4/5/2046 0:00	8130	164.0997	5/21/2046 0:00	8176	164.1573	7/6/2046 0:00	8222	164.2145
2/19/2046 0:00	8085	164.0431	4/6/2046 0:00	8131	164.101	5/22/2046 0:00	8177	164.1585	7/7/2046 0:00	8223	164.2157
2/20/2046 0:00	8086	164.0443	4/7/2046 0:00	8132	164.1022	5/23/2046 0:00	8178	164.1597	7/8/2046 0:00	8224	164.217
2/21/2046 0:00	8087	164.0456	4/8/2046 0:00	8133	164.1035	5/24/2046 0:00	8179	164.161	7/9/2046 0:00	8225	164.2182
2/22/2046 0:00	8088	164.0469	4/9/2046 0:00	8134	164.1047	5/25/2046 0:00	8180	164.1622	7/10/2046 0:00	8226	164.2194
2/23/2046 0:00	8089	164.0481	4/10/2046 0:00	8135	164.106	5/26/2046 0:00	8181	164.1635	7/11/2046 0:00	8227	164.2207
2/24/2046 0:00	8090	164.0494	4/11/2046 0:00	8136	164.1072	5/27/2046 0:00	8182	164.1647	7/12/2046 0:00	8228	164.2219
2/25/2046 0:00	8091	164.0507	4/12/2046 0:00	8137	164.1085	5/28/2046 0:00	8183	164.166	7/13/2046 0:00	8229	164.2232
2/26/2046 0:00	8092	164.0519	4/13/2046 0:00	8138	164.1097	5/29/2046 0:00	8184	164.1672	7/14/2046 0:00	8230	164.2244
2/27/2046 0:00	8093	164.0532	4/14/2046 0:00	8139	164.111	5/30/2046 0:00	8185	164.1685	7/15/2046 0:00	8231	164.2256
2/28/2046 0:00	8094	164.0544	4/15/2046 0:00	8140	164.1122	5/31/2046 0:00	8186	164.1697	7/16/2046 0:00	8232	164.2269
3/1/2046 0:00	8095	164.0557	4/16/2046 0:00	8141	164.1135	6/1/2046 0:00	8187	164.171	7/17/2046 0:00	8233	164.2281
3/2/2046 0:00	8096	164.057	4/17/2046 0:00	8142	164.1147	6/2/2046 0:00	8188	164.1722	7/18/2046 0:00	8234	164.2294
3/3/2046 0:00	8097	164.0582	4/18/2046 0:00	8143	164.116	6/3/2046 0:00	8189	164.1735	7/19/2046 0:00	8235	164.2306
3/4/2046 0:00	8098	164.0595	4/19/2046 0:00	8144	164.1173	6/4/2046 0:00	8190	164.1747	7/20/2046 0:00	8236	164.2318
3/5/2046 0:00	8099	164.0607	4/20/2046 0:00	8145	164.1185	6/5/2046 0:00	8191	164.1759	7/21/2046 0:00	8237	164.2331
3/6/2046 0:00	8100	164.062	4/21/2046 0:00	8146	164.1198	6/6/2046 0:00	8192	164.1772	7/22/2046 0:00	8238	164.2343
3/7/2046 0:00	8101	164.0633	4/22/2046 0:00	8147	164.121	6/7/2046 0:00	8193	164.1784	7/23/2046 0:00	8239	164.2356
3/8/2046 0:00	8102	164.0645	4/23/2046 0:00	8148	164.1223	6/8/2046 0:00	8194	164.1797	7/24/2046 0:00	8240	164.2368
3/9/2046 0:00	8103	164.0658	4/24/2046 0:00	8149	164.1235	6/9/2046 0:00	8195	164.1809	7/25/2046 0:00	8241	164.238
3/10/2046 0:00	8104	164.067	4/25/2046 0:00	8150	164.1248	6/10/2046 0:00	8196	164.1822	7/26/2046 0:00	8242	164.2393
3/11/2046 0:00	8105	164.0683	4/26/2046 0:00	8151	164.126	6/11/2046 0:00	8197	164.1834	7/27/2046 0:00	8243	164.2405
3/12/2046 0:00	8106	164.0695	4/27/2046 0:00	8152	164.1273	6/12/2046 0:00	8198	164.1847	7/28/2046 0:00	8244	164.2417
3/13/2046 0:00	8107	164.0708	4/28/2046 0:00	8153	164.1285	6/13/2046 0:00	8199	164.1859	7/29/2046 0:00	8245	164.243
3/14/2046 0:00	8108	164.0721	4/29/2046 0:00	8154	164.1298	6/14/2046 0:00	8200	164.1872	7/30/2046 0:00	8246	164.2442
3/15/2046 0:00	8109	164.0733	4/30/2046 0:00	8155	164.131	6/15/2046 0:00	8201	164.1884	7/31/2046 0:00	8247	164.2454
3/16/2046 0:00	8110	164.0746	5/1/2046 0:00	8156	164.1323	6/16/2046 0:00	8202	164.1896	8/1/2046 0:00	8248	164.2467
3/17/2046 0:00	8111	164.0758	5/2/2046 0:00	8157	164.1335	6/17/2046 0:00	8203	164.1909	8/2/2046 0:00	8249	164.2479
3/18/2046 0:00	8112	164.0771	5/3/2046 0:00	8158	164.1348	6/18/2046 0:00	8204	164.1921	8/3/2046 0:00	8250	164.2492
3/19/2046 0:00	8113	164.0783	5/4/2046 0:00	8159	164.136	6/19/2046 0:00	8205	164.1934	8/4/2046 0:00	8251	164.2504
3/20/2046 0:00	8114	164.0796	5/5/2046 0:00	8160	164.1373	6/20/2046 0:00	8206	164.1946	8/5/2046 0:00	8252	164.2516
3/21/2046 0:00	8115	164.0809	5/6/2046 0:00	8161	164.1385	6/21/2046 0:00	8207	164.1959	8/6/2046 0:00	8253	164.2529
3/22/2046 0:00	8116	164.0821	5/7/2046 0:00	8162	164.1398	6/22/2046 0:00	8208	164.1971	8/7/2046 0:00	8254	164.2541
3/23/2046 0:00	8117	164.0834	5/8/2046 0:00	8163	164.141	6/23/2046 0:00	8209	164.1983	8/8/2046 0:00	8255	164.2553
3/24/2046 0:00	8118	164.0846	5/9/2046 0:00	8164	164.1423	6/24/2046 0:00	8210	164.1996	8/9/2046 0:00	8256	164.2566
3/25/2046 0:00	8119	164.0859	5/10/2046 0:00	8165	164.1435	6/25/2046 0:00	8211	164.2008	8/10/2046 0:00	8257	164.2578
3/26/2046 0:00	8120	164.0871	5/11/2046 0:00	8166	164.1448	6/26/2046 0:00	8212	164.2021	8/11/2046 0:00	8258	164.259
3/27/2046 0:00	8121	164.0884	5/12/2046 0:00	8167	164.146	6/27/2046 0:00	8213	164.2033	8/12/2046 0:00	8259	164.2603
3/28/2046 0:00	8122	164.0897	5/13/2046 0:00	8168	164.1473	6/28/2046 0:00	8214	164.2046	8/13/2046 0:00	8260	164.2615
3/29/2046 0:00	8123	164.0909	5/14/2046 0:00	8169	164.1485	6/29/2046 0:00	8215	164.2058	8/14/2046 0:00	8261	164.2628
3/30/2046 0:00	8124	164.0922	5/15/2046 0:00	8170	164.1498	6/30/2046 0:00	8216	164.207	8/15/2046 0:00	8262	164.264
3/31/2046 0:00	8125	164.0934	5/16/2046 0:00	8171	164.151	7/1/2046 0:00	8217	164.2083	8/16/2046 0:00	8263	164.2652
4/1/2046 0:00	8126	164.0947	5/17/2046 0:00	8172	164.1523	7/2/2046 0:00	8218	164.2095	8/17/2046 0:00	8264	164.2665
4/2/2046 0:00	8127	164.0959	5/18/2046 0:00	8173	164.1535	7/3/2046 0:00	8219	164.2108	8/18/2046 0:00	8265	164.2677
4/3/2046 0:00	8128	164.0972	5/19/2046 0:00	8174	164.1548	7/4/2046 0:00	8220	164.212	8/19/2046 0:00	8266	164.2689
4/4/2046 0:00	8129	164.0984	5/20/2046 0:00	8175	164.156	7/5/2046 0:00	8221	164.2132	8/20/2046 0:00	8267	164.2702

8/21/2046 0:00	8268	164.2714	10/6/2046 0:00	8314	164.328	11/21/2046 0:00	8360	164.3843	1/6/2047 0:00	8406	164.4402
8/22/2046 0:00	8269	164.2726	10/7/2046 0:00	8315	164.3292	11/22/2046 0:00	8361	164.3855	1/7/2047 0:00	8407	164.4415
8/23/2046 0:00	8270	164.2739	10/8/2046 0:00	8316	164.3304	11/23/2046 0:00	8362	164.3867	1/8/2047 0:00	8408	164.4427
8/24/2046 0:00	8271	164.2751	10/9/2046 0:00	8317	164.3317	11/24/2046 0:00	8363	164.3879	1/9/2047 0:00	8409	164.4439
8/25/2046 0:00	8272	164.2763	10/10/2046 0:00	8318	164.3329	11/25/2046 0:00	8364	164.3891	1/10/2047 0:00	8410	164.4451
8/26/2046 0:00	8273	164.2776	10/11/2046 0:00	8319	164.3341	11/26/2046 0:00	8365	164.3904	1/11/2047 0:00	8411	164.4463
8/27/2046 0:00	8274	164.2788	10/12/2046 0:00	8320	164.3353	11/27/2046 0:00	8366	164.3916	1/12/2047 0:00	8412	164.4475
8/28/2046 0:00	8275	164.28	10/13/2046 0:00	8321	164.3366	11/28/2046 0:00	8367	164.3928	1/13/2047 0:00	8413	164.4487
8/29/2046 0:00	8276	164.2813	10/14/2046 0:00	8322	164.3378	11/29/2046 0:00	8368	164.394	1/14/2047 0:00	8414	164.4499
8/30/2046 0:00	8277	164.2825	10/15/2046 0:00	8323	164.339	11/30/2046 0:00	8369	164.3952	1/15/2047 0:00	8415	164.4512
8/31/2046 0:00	8278	164.2837	10/16/2046 0:00	8324	164.3402	12/1/2046 0:00	8370	164.3965	1/16/2047 0:00	8416	164.4524
9/1/2046 0:00	8279	164.285	10/17/2046 0:00	8325	164.3415	12/2/2046 0:00	8371	164.3977	1/17/2047 0:00	8417	164.4536
9/2/2046 0:00	8280	164.2862	10/18/2046 0:00	8326	164.3427	12/3/2046 0:00	8372	164.3989	1/18/2047 0:00	8418	164.4548
9/3/2046 0:00	8281	164.2874	10/19/2046 0:00	8327	164.3439	12/4/2046 0:00	8373	164.4001	1/19/2047 0:00	8419	164.456
9/4/2046 0:00	8282	164.2886	10/20/2046 0:00	8328	164.3451	12/5/2046 0:00	8374	164.4013	1/20/2047 0:00	8420	164.4572
9/5/2046 0:00	8283	164.2899	10/21/2046 0:00	8329	164.3464	12/6/2046 0:00	8375	164.4026	1/21/2047 0:00	8421	164.4584
9/6/2046 0:00	8284	164.2911	10/22/2046 0:00	8330	164.3476	12/7/2046 0:00	8376	164.4038	1/22/2047 0:00	8422	164.4596
9/7/2046 0:00	8285	164.2923	10/23/2046 0:00	8331	164.3488	12/8/2046 0:00	8377	164.405	1/23/2047 0:00	8423	164.4608
9/8/2046 0:00	8286	164.2936	10/24/2046 0:00	8332	164.35	12/9/2046 0:00	8378	164.4062	1/24/2047 0:00	8424	164.4621
9/9/2046 0:00	8287	164.2948	10/25/2046 0:00	8333	164.3513	12/10/2046 0:00	8379	164.4074	1/25/2047 0:00	8425	164.4633
9/10/2046 0:00	8288	164.296	10/26/2046 0:00	8334	164.3525	12/11/2046 0:00	8380	164.4086	1/26/2047 0:00	8426	164.4645
9/11/2046 0:00	8289	164.2973	10/27/2046 0:00	8335	164.3537	12/12/2046 0:00	8381	164.4099	1/27/2047 0:00	8427	164.4657
9/12/2046 0:00	8290	164.2985	10/28/2046 0:00	8336	164.3549	12/13/2046 0:00	8382	164.4111	1/28/2047 0:00	8428	164.4669
9/13/2046 0:00	8291	164.2997	10/29/2046 0:00	8337	164.3562	12/14/2046 0:00	8383	164.4123	1/29/2047 0:00	8429	164.4681
9/14/2046 0:00	8292	164.301	10/30/2046 0:00	8338	164.3574	12/15/2046 0:00	8384	164.4135	1/30/2047 0:00	8430	164.4693
9/15/2046 0:00	8293	164.3022	10/31/2046 0:00	8339	164.3586	12/16/2046 0:00	8385	164.4147	1/31/2047 0:00	8431	164.4705
9/16/2046 0:00	8294	164.3034	11/1/2046 0:00	8340	164.3598	12/17/2046 0:00	8386	164.4159	2/1/2047 0:00	8432	164.4717
9/17/2046 0:00	8295	164.3046	11/2/2046 0:00	8341	164.3611	12/18/2046 0:00	8387	164.4172	2/2/2047 0:00	8433	164.473
9/18/2046 0:00	8296	164.3059	11/3/2046 0:00	8342	164.3623	12/19/2046 0:00	8388	164.4184	2/3/2047 0:00	8434	164.4742
9/19/2046 0:00	8297	164.3071	11/4/2046 0:00	8343	164.3635	12/20/2046 0:00	8389	164.4196	2/4/2047 0:00	8435	164.4754
9/20/2046 0:00	8298	164.3083	11/5/2046 0:00	8344	164.3647	12/21/2046 0:00	8390	164.4208	2/5/2047 0:00	8436	164.4766
9/21/2046 0:00	8299	164.3096	11/6/2046 0:00	8345	164.3659	12/22/2046 0:00	8391	164.422	2/6/2047 0:00	8437	164.4778
9/22/2046 0:00	8300	164.3108	11/7/2046 0:00	8346	164.3672	12/23/2046 0:00	8392	164.4232	2/7/2047 0:00	8438	164.479
9/23/2046 0:00	8301	164.312	11/8/2046 0:00	8347	164.3684	12/24/2046 0:00	8393	164.4245	2/8/2047 0:00	8439	164.4802
9/24/2046 0:00	8302	164.3133	11/9/2046 0:00	8348	164.3696	12/25/2046 0:00	8394	164.4257	2/9/2047 0:00	8440	164.4814
9/25/2046 0:00	8303	164.3145	11/10/2046 0:00	8349	164.3708	12/26/2046 0:00	8395	164.4269	2/10/2047 0:00	8441	164.4826
9/26/2046 0:00	8304	164.3157	11/11/2046 0:00	8350	164.3721	12/27/2046 0:00	8396	164.4281	2/11/2047 0:00	8442	164.4838
9/27/2046 0:00	8305	164.3169	11/12/2046 0:00	8351	164.3733	12/28/2046 0:00	8397	164.4293	2/12/2047 0:00	8443	164.485
9/28/2046 0:00	8306	164.3182	11/13/2046 0:00	8352	164.3745	12/29/2046 0:00	8398	164.4305	2/13/2047 0:00	8444	164.4862
9/29/2046 0:00	8307	164.3194	11/14/2046 0:00	8353	164.3757	12/30/2046 0:00	8399	164.4317	2/14/2047 0:00	8445	164.4875
9/30/2046 0:00	8308	164.3206	11/15/2046 0:00	8354	164.3769	12/31/2046 0:00	8400	164.433	2/15/2047 0:00	8446	164.4887
10/1/2046 0:00	8309	164.3218	11/16/2046 0:00	8355	164.3782	1/1/2047 0:00	8401	164.4342	2/16/2047 0:00	8447	164.4899
10/2/2046 0:00	8310	164.3231	11/17/2046 0:00	8356	164.3794	1/2/2047 0:00	8402	164.4354	2/17/2047 0:00	8448	164.4911
10/3/2046 0:00	8311	164.3243	11/18/2046 0:00	8357	164.3806	1/3/2047 0:00	8403	164.4366	2/18/2047 0:00	8449	164.4923
10/4/2046 0:00	8312	164.3255	11/19/2046 0:00	8358	164.3818	1/4/2047 0:00	8404	164.4378	2/19/2047 0:00	8450	164.4935
10/5/2046 0:00	8313	164.3268	11/20/2046 0:00	8359	164.383	1/5/2047 0:00	8405	164.439	2/20/2047 0:00	8451	164.4947

2/21/2047 0:00	8452	164.4959	4/8/2047 0:00	8498	164.5513	5/24/2047 0:00	8544	164.6063	7/9/2047 0:00	8590	164.6611
2/22/2047 0:00	8453	164.4971	4/9/2047 0:00	8499	164.5525	5/25/2047 0:00	8545	164.6075	7/10/2047 0:00	8591	164.6623
2/23/2047 0:00	8454	164.4983	4/10/2047 0:00	8500	164.5537	5/26/2047 0:00	8546	164.6087	7/11/2047 0:00	8592	164.6635
2/24/2047 0:00	8455	164.4995	4/11/2047 0:00	8501	164.5549	5/27/2047 0:00	8547	164.6099	7/12/2047 0:00	8593	164.6647
2/25/2047 0:00	8456	164.5007	4/12/2047 0:00	8502	164.5561	5/28/2047 0:00	8548	164.6111	7/13/2047 0:00	8594	164.6659
2/26/2047 0:00	8457	164.5019	4/13/2047 0:00	8503	164.5573	5/29/2047 0:00	8549	164.6123	7/14/2047 0:00	8595	164.667
2/27/2047 0:00	8458	164.5031	4/14/2047 0:00	8504	164.5585	5/30/2047 0:00	8550	164.6135	7/15/2047 0:00	8596	164.6682
2/28/2047 0:00	8459	164.5044	4/15/2047 0:00	8505	164.5597	5/31/2047 0:00	8551	164.6147	7/16/2047 0:00	8597	164.6694
3/1/2047 0:00	8460	164.5056	4/16/2047 0:00	8506	164.5609	6/1/2047 0:00	8552	164.6159	7/17/2047 0:00	8598	164.6706
3/2/2047 0:00	8461	164.5068	4/17/2047 0:00	8507	164.5621	6/2/2047 0:00	8553	164.6171	7/18/2047 0:00	8599	164.6718
3/3/2047 0:00	8462	164.508	4/18/2047 0:00	8508	164.5633	6/3/2047 0:00	8554	164.6183	7/19/2047 0:00	8600	164.673
3/4/2047 0:00	8463	164.5092	4/19/2047 0:00	8509	164.5645	6/4/2047 0:00	8555	164.6195	7/20/2047 0:00	8601	164.6742
3/5/2047 0:00	8464	164.5104	4/20/2047 0:00	8510	164.5657	6/5/2047 0:00	8556	164.6207	7/21/2047 0:00	8602	164.6754
3/6/2047 0:00	8465	164.5116	4/21/2047 0:00	8511	164.5669	6/6/2047 0:00	8557	164.6219	7/22/2047 0:00	8603	164.6765
3/7/2047 0:00	8466	164.5128	4/22/2047 0:00	8512	164.5681	6/7/2047 0:00	8558	164.623	7/23/2047 0:00	8604	164.6777
3/8/2047 0:00	8467	164.514	4/23/2047 0:00	8513	164.5693	6/8/2047 0:00	8559	164.6242	7/24/2047 0:00	8605	164.6789
3/9/2047 0:00	8468	164.5152	4/24/2047 0:00	8514	164.5705	6/9/2047 0:00	8560	164.6254	7/25/2047 0:00	8606	164.6801
3/10/2047 0:00	8469	164.5164	4/25/2047 0:00	8515	164.5717	6/10/2047 0:00	8561	164.6266	7/26/2047 0:00	8607	164.6813
3/11/2047 0:00	8470	164.5176	4/26/2047 0:00	8516	164.5729	6/11/2047 0:00	8562	164.6278	7/27/2047 0:00	8608	164.6825
3/12/2047 0:00	8471	164.5188	4/27/2047 0:00	8517	164.5741	6/12/2047 0:00	8563	164.629	7/28/2047 0:00	8609	164.6837
3/13/2047 0:00	8472	164.52	4/28/2047 0:00	8518	164.5753	6/13/2047 0:00	8564	164.6302	7/29/2047 0:00	8610	164.6848
3/14/2047 0:00	8473	164.5212	4/29/2047 0:00	8519	164.5765	6/14/2047 0:00	8565	164.6314	7/30/2047 0:00	8611	164.686
3/15/2047 0:00	8474	164.5224	4/30/2047 0:00	8520	164.5776	6/15/2047 0:00	8566	164.6326	7/31/2047 0:00	8612	164.6872
3/16/2047 0:00	8475	164.5236	5/1/2047 0:00	8521	164.5788	6/16/2047 0:00	8567	164.6338	8/1/2047 0:00	8613	164.6884
3/17/2047 0:00	8476	164.5248	5/2/2047 0:00	8522	164.58	6/17/2047 0:00	8568	164.635	8/2/2047 0:00	8614	164.6896
3/18/2047 0:00	8477	164.526	5/3/2047 0:00	8523	164.5812	6/18/2047 0:00	8569	164.6361	8/3/2047 0:00	8615	164.6908
3/19/2047 0:00	8478	164.5272	5/4/2047 0:00	8524	164.5824	6/19/2047 0:00	8570	164.6373	8/4/2047 0:00	8616	164.6919
3/20/2047 0:00	8479	164.5284	5/5/2047 0:00	8525	164.5836	6/20/2047 0:00	8571	164.6385	8/5/2047 0:00	8617	164.6931
3/21/2047 0:00	8480	164.5296	5/6/2047 0:00	8526	164.5848	6/21/2047 0:00	8572	164.6397	8/6/2047 0:00	8618	164.6943
3/22/2047 0:00	8481	164.5308	5/7/2047 0:00	8527	164.586	6/22/2047 0:00	8573	164.6409	8/7/2047 0:00	8619	164.6955
3/23/2047 0:00	8482	164.5321	5/8/2047 0:00	8528	164.5872	6/23/2047 0:00	8574	164.6421	8/8/2047 0:00	8620	164.6967
3/24/2047 0:00	8483	164.5333	5/9/2047 0:00	8529	164.5884	6/24/2047 0:00	8575	164.6433	8/9/2047 0:00	8621	164.6979
3/25/2047 0:00	8484	164.5345	5/10/2047 0:00	8530	164.5896	6/25/2047 0:00	8576	164.6445	8/10/2047 0:00	8622	164.699
3/26/2047 0:00	8485	164.5357	5/11/2047 0:00	8531	164.5908	6/26/2047 0:00	8577	164.6457	8/11/2047 0:00	8623	164.7002
3/27/2047 0:00	8486	164.5369	5/12/2047 0:00	8532	164.592	6/27/2047 0:00	8578	164.6469	8/12/2047 0:00	8624	164.7014
3/28/2047 0:00	8487	164.5381	5/13/2047 0:00	8533	164.5932	6/28/2047 0:00	8579	164.648	8/13/2047 0:00	8625	164.7026
3/29/2047 0:00	8488	164.5393	5/14/2047 0:00	8534	164.5944	6/29/2047 0:00	8580	164.6492	8/14/2047 0:00	8626	164.7038
3/30/2047 0:00	8489	164.5405	5/15/2047 0:00	8535	164.5956	6/30/2047 0:00	8581	164.6504	8/15/2047 0:00	8627	164.705
3/31/2047 0:00	8490	164.5417	5/16/2047 0:00	8536	164.5968	7/1/2047 0:00	8582	164.6516	8/16/2047 0:00	8628	164.7061
4/1/2047 0:00	8491	164.5429	5/17/2047 0:00	8537	164.598	7/2/2047 0:00	8583	164.6528	8/17/2047 0:00	8629	164.7073
4/2/2047 0:00	8492	164.5441	5/18/2047 0:00	8538	164.5992	7/3/2047 0:00	8584	164.654	8/18/2047 0:00	8630	164.7085
4/3/2047 0:00	8493	164.5453	5/19/2047 0:00	8539	164.6004	7/4/2047 0:00	8585	164.6552	8/19/2047 0:00	8631	164.7097
4/4/2047 0:00	8494	164.5465	5/20/2047 0:00	8540	164.6016	7/5/2047 0:00	8586	164.6564	8/20/2047 0:00	8632	164.7109
4/5/2047 0:00	8495	164.5477	5/21/2047 0:00	8541	164.6028	7/6/2047 0:00	8587	164.6576	8/21/2047 0:00	8633	164.712
4/6/2047 0:00	8496	164.5489	5/22/2047 0:00	8542	164.604	7/7/2047 0:00	8588	164.6587	8/22/2047 0:00	8634	164.7132
4/7/2047 0:00	8497	164.5501	5/23/2047 0:00	8543	164.6051	7/8/2047 0:00	8589	164.6599	8/23/2047 0:00	8635	164.7144

8/24/2047 0:00	8636	164.7156	10/9/2047 0:00	8682	164.7698	11/24/2047 0:00	8728	164.8237	1/9/2048 0:00	8774	164.8773
8/25/2047 0:00	8637	164.7168	10/10/2047 0:00	8683	164.771	11/25/2047 0:00	8729	164.8249	1/10/2048 0:00	8775	164.8785
8/26/2047 0:00	8638	164.718	10/11/2047 0:00	8684	164.7721	11/26/2047 0:00	8730	164.826	1/11/2048 0:00	8776	164.8796
8/27/2047 0:00	8639	164.7191	10/12/2047 0:00	8685	164.7733	11/27/2047 0:00	8731	164.8272	1/12/2048 0:00	8777	164.8808
8/28/2047 0:00	8640	164.7203	10/13/2047 0:00	8686	164.7745	11/28/2047 0:00	8732	164.8284	1/13/2048 0:00	8778	164.882
8/29/2047 0:00	8641	164.7215	10/14/2047 0:00	8687	164.7757	11/29/2047 0:00	8733	164.8295	1/14/2048 0:00	8779	164.8831
8/30/2047 0:00	8642	164.7227	10/15/2047 0:00	8688	164.7768	11/30/2047 0:00	8734	164.8307	1/15/2048 0:00	8780	164.8843
8/31/2047 0:00	8643	164.7239	10/16/2047 0:00	8689	164.778	12/1/2047 0:00	8735	164.8319	1/16/2048 0:00	8781	164.8854
9/1/2047 0:00	8644	164.725	10/17/2047 0:00	8690	164.7792	12/2/2047 0:00	8736	164.833	1/17/2048 0:00	8782	164.8866
9/2/2047 0:00	8645	164.7262	10/18/2047 0:00	8691	164.7804	12/3/2047 0:00	8737	164.8342	1/18/2048 0:00	8783	164.8878
9/3/2047 0:00	8646	164.7274	10/19/2047 0:00	8692	164.7815	12/4/2047 0:00	8738	164.8354	1/19/2048 0:00	8784	164.8889
9/4/2047 0:00	8647	164.7286	10/20/2047 0:00	8693	164.7827	12/5/2047 0:00	8739	164.8365	1/20/2048 0:00	8785	164.8901
9/5/2047 0:00	8648	164.7298	10/21/2047 0:00	8694	164.7839	12/6/2047 0:00	8740	164.8377	1/21/2048 0:00	8786	164.8912
9/6/2047 0:00	8649	164.7309	10/22/2047 0:00	8695	164.785	12/7/2047 0:00	8741	164.8389	1/22/2048 0:00	8787	164.8924
9/7/2047 0:00	8650	164.7321	10/23/2047 0:00	8696	164.7862	12/8/2047 0:00	8742	164.84	1/23/2048 0:00	8788	164.8936
9/8/2047 0:00	8651	164.7333	10/24/2047 0:00	8697	164.7874	12/9/2047 0:00	8743	164.8412	1/24/2048 0:00	8789	164.8947
9/9/2047 0:00	8652	164.7345	10/25/2047 0:00	8698	164.7886	12/10/2047 0:00	8744	164.8424	1/25/2048 0:00	8790	164.8959
9/10/2047 0:00	8653	164.7357	10/26/2047 0:00	8699	164.7897	12/11/2047 0:00	8745	164.8435	1/26/2048 0:00	8791	164.8971
9/11/2047 0:00	8654	164.7368	10/27/2047 0:00	8700	164.7909	12/12/2047 0:00	8746	164.8447	1/27/2048 0:00	8792	164.8982
9/12/2047 0:00	8655	164.738	10/28/2047 0:00	8701	164.7921	12/13/2047 0:00	8747	164.8459	1/28/2048 0:00	8793	164.8994
9/13/2047 0:00	8656	164.7392	10/29/2047 0:00	8702	164.7933	12/14/2047 0:00	8748	164.847	1/29/2048 0:00	8794	164.9005
9/14/2047 0:00	8657	164.7404	10/30/2047 0:00	8703	164.7944	12/15/2047 0:00	8749	164.8482	1/30/2048 0:00	8795	164.9017
9/15/2047 0:00	8658	164.7415	10/31/2047 0:00	8704	164.7956	12/16/2047 0:00	8750	164.8494	1/31/2048 0:00	8796	164.9029
9/16/2047 0:00	8659	164.7427	11/1/2047 0:00	8705	164.7968	12/17/2047 0:00	8751	164.8505	2/1/2048 0:00	8797	164.904
9/17/2047 0:00	8660	164.7439	11/2/2047 0:00	8706	164.7979	12/18/2047 0:00	8752	164.8517	2/2/2048 0:00	8798	164.9052
9/18/2047 0:00	8661	164.7451	11/3/2047 0:00	8707	164.7991	12/19/2047 0:00	8753	164.8529	2/3/2048 0:00	8799	164.9063
9/19/2047 0:00	8662	164.7463	11/4/2047 0:00	8708	164.8003	12/20/2047 0:00	8754	164.854	2/4/2048 0:00	8800	164.9075
9/20/2047 0:00	8663	164.7474	11/5/2047 0:00	8709	164.8015	12/21/2047 0:00	8755	164.8552	2/5/2048 0:00	8801	164.9086
9/21/2047 0:00	8664	164.7486	11/6/2047 0:00	8710	164.8026	12/22/2047 0:00	8756	164.8564	2/6/2048 0:00	8802	164.9098
9/22/2047 0:00	8665	164.7498	11/7/2047 0:00	8711	164.8038	12/23/2047 0:00	8757	164.8575	2/7/2048 0:00	8803	164.911
9/23/2047 0:00	8666	164.751	11/8/2047 0:00	8712	164.805	12/24/2047 0:00	8758	164.8587	2/8/2048 0:00	8804	164.9121
9/24/2047 0:00	8667	164.7521	11/9/2047 0:00	8713	164.8061	12/25/2047 0:00	8759	164.8599	2/9/2048 0:00	8805	164.9133
9/25/2047 0:00	8668	164.7533	11/10/2047 0:00	8714	164.8073	12/26/2047 0:00	8760	164.861	2/10/2048 0:00	8806	164.9144
9/26/2047 0:00	8669	164.7545	11/11/2047 0:00	8715	164.8085	12/27/2047 0:00	8761	164.8622	2/11/2048 0:00	8807	164.9156
9/27/2047 0:00	8670	164.7557	11/12/2047 0:00	8716	164.8097	12/28/2047 0:00	8762	164.8633	2/12/2048 0:00	8808	164.9168
9/28/2047 0:00	8671	164.7569	11/13/2047 0:00	8717	164.8108	12/29/2047 0:00	8763	164.8645	2/13/2048 0:00	8809	164.9179
9/29/2047 0:00	8672	164.758	11/14/2047 0:00	8718	164.812	12/30/2047 0:00	8764	164.8657	2/14/2048 0:00	8810	164.9191
9/30/2047 0:00	8673	164.7592	11/15/2047 0:00	8719	164.8132	12/31/2047 0:00	8765	164.8668	2/15/2048 0:00	8811	164.9202
10/1/2047 0:00	8674	164.7604	11/16/2047 0:00	8720	164.8143	1/1/2048 0:00	8766	164.868	2/16/2048 0:00	8812	164.9214
10/2/2047 0:00	8675	164.7616	11/17/2047 0:00	8721	164.8155	1/2/2048 0:00	8767	164.8692	2/17/2048 0:00	8813	164.9225
10/3/2047 0:00	8676	164.7627	11/18/2047 0:00	8722	164.8167	1/3/2048 0:00	8768	164.8703	2/18/2048 0:00	8814	164.9237
10/4/2047 0:00	8677	164.7639	11/19/2047 0:00	8723	164.8178	1/4/2048 0:00	8769	164.8715	2/19/2048 0:00	8815	164.9249
10/5/2047 0:00	8678	164.7651	11/20/2047 0:00	8724	164.819	1/5/2048 0:00	8770	164.8727	2/20/2048 0:00	8816	164.926
10/6/2047 0:00	8679	164.7663	11/21/2047 0:00	8725	164.8202	1/6/2048 0:00	8771	164.8738	2/21/2048 0:00	8817	164.9272
10/7/2047 0:00	8680	164.7674	11/22/2047 0:00	8726	164.8213	1/7/2048 0:00	8772	164.875	2/22/2048 0:00	8818	164.9283
10/8/2047 0:00	8681	164.7686	11/23/2047 0:00	8727	164.8225	1/8/2048 0:00	8773	164.8761	2/23/2048 0:00	8819	164.9295

2/24/2048 0:00	8820	164.9306	4/10/2048 0:00	8866	164.9837	5/26/2048 0:00	8912	165.0365	7/11/2048 0:00	8958	165.089
2/25/2048 0:00	8821	164.9318	4/11/2048 0:00	8867	164.9849	5/27/2048 0:00	8913	165.0376	7/12/2048 0:00	8959	165.0902
2/26/2048 0:00	8822	164.933	4/12/2048 0:00	8868	164.986	5/28/2048 0:00	8914	165.0388	7/13/2048 0:00	8960	165.0913
2/27/2048 0:00	8823	164.9341	4/13/2048 0:00	8869	164.9872	5/29/2048 0:00	8915	165.0399	7/14/2048 0:00	8961	165.0924
2/28/2048 0:00	8824	164.9353	4/14/2048 0:00	8870	164.9883	5/30/2048 0:00	8916	165.0411	7/15/2048 0:00	8962	165.0936
2/29/2048 0:00	8825	164.9364	4/15/2048 0:00	8871	164.9895	5/31/2048 0:00	8917	165.0422	7/16/2048 0:00	8963	165.0947
3/1/2048 0:00	8826	164.9376	4/16/2048 0:00	8872	164.9906	6/1/2048 0:00	8918	165.0434	7/17/2048 0:00	8964	165.0958
3/2/2048 0:00	8827	164.9387	4/17/2048 0:00	8873	164.9918	6/2/2048 0:00	8919	165.0445	7/18/2048 0:00	8965	165.097
3/3/2048 0:00	8828	164.9399	4/18/2048 0:00	8874	164.9929	6/3/2048 0:00	8920	165.0457	7/19/2048 0:00	8966	165.0981
3/4/2048 0:00	8829	164.9411	4/19/2048 0:00	8875	164.9941	6/4/2048 0:00	8921	165.0468	7/20/2048 0:00	8967	165.0993
3/5/2048 0:00	8830	164.9422	4/20/2048 0:00	8876	164.9952	6/5/2048 0:00	8922	165.0479	7/21/2048 0:00	8968	165.1004
3/6/2048 0:00	8831	164.9434	4/21/2048 0:00	8877	164.9964	6/6/2048 0:00	8923	165.0491	7/22/2048 0:00	8969	165.1015
3/7/2048 0:00	8832	164.9445	4/22/2048 0:00	8878	164.9975	6/7/2048 0:00	8924	165.0502	7/23/2048 0:00	8970	165.1027
3/8/2048 0:00	8833	164.9457	4/23/2048 0:00	8879	164.9987	6/8/2048 0:00	8925	165.0514	7/24/2048 0:00	8971	165.1038
3/9/2048 0:00	8834	164.9468	4/24/2048 0:00	8880	164.9998	6/9/2048 0:00	8926	165.0525	7/25/2048 0:00	8972	165.1049
3/10/2048 0:00	8835	164.948	4/25/2048 0:00	8881	165.001	6/10/2048 0:00	8927	165.0537	7/26/2048 0:00	8973	165.1061
3/11/2048 0:00	8836	164.9491	4/26/2048 0:00	8882	165.0021	6/11/2048 0:00	8928	165.0548	7/27/2048 0:00	8974	165.1072
3/12/2048 0:00	8837	164.9503	4/27/2048 0:00	8883	165.0033	6/12/2048 0:00	8929	165.0559	7/28/2048 0:00	8975	165.1084
3/13/2048 0:00	8838	164.9514	4/28/2048 0:00	8884	165.0044	6/13/2048 0:00	8930	165.0571	7/29/2048 0:00	8976	165.1095
3/14/2048 0:00	8839	164.9526	4/29/2048 0:00	8885	165.0055	6/14/2048 0:00	8931	165.0582	7/30/2048 0:00	8977	165.1106
3/15/2048 0:00	8840	164.9538	4/30/2048 0:00	8886	165.0067	6/15/2048 0:00	8932	165.0594	7/31/2048 0:00	8978	165.1118
3/16/2048 0:00	8841	164.9549	5/1/2048 0:00	8887	165.0078	6/16/2048 0:00	8933	165.0605	8/1/2048 0:00	8979	165.1129
3/17/2048 0:00	8842	164.9561	5/2/2048 0:00	8888	165.009	6/17/2048 0:00	8934	165.0616	8/2/2048 0:00	8980	165.114
3/18/2048 0:00	8843	164.9572	5/3/2048 0:00	8889	165.0101	6/18/2048 0:00	8935	165.0628	8/3/2048 0:00	8981	165.1152
3/19/2048 0:00	8844	164.9584	5/4/2048 0:00	8890	165.0113	6/19/2048 0:00	8936	165.0639	8/4/2048 0:00	8982	165.1163
3/20/2048 0:00	8845	164.9595	5/5/2048 0:00	8891	165.0124	6/20/2048 0:00	8937	165.0651	8/5/2048 0:00	8983	165.1174
3/21/2048 0:00	8846	164.9607	5/6/2048 0:00	8892	165.0136	6/21/2048 0:00	8938	165.0662	8/6/2048 0:00	8984	165.1186
3/22/2048 0:00	8847	164.9618	5/7/2048 0:00	8893	165.0147	6/22/2048 0:00	8939	165.0674	8/7/2048 0:00	8985	165.1197
3/23/2048 0:00	8848	164.963	5/8/2048 0:00	8894	165.0159	6/23/2048 0:00	8940	165.0685	8/8/2048 0:00	8986	165.1209
3/24/2048 0:00	8849	164.9641	5/9/2048 0:00	8895	165.017	6/24/2048 0:00	8941	165.0696	8/9/2048 0:00	8987	165.122
3/25/2048 0:00	8850	164.9653	5/10/2048 0:00	8896	165.0182	6/25/2048 0:00	8942	165.0708	8/10/2048 0:00	8988	165.1231
3/26/2048 0:00	8851	164.9664	5/11/2048 0:00	8897	165.0193	6/26/2048 0:00	8943	165.0719	8/11/2048 0:00	8989	165.1243
3/27/2048 0:00	8852	164.9676	5/12/2048 0:00	8898	165.0205	6/27/2048 0:00	8944	165.0731	8/12/2048 0:00	8990	165.1254
3/28/2048 0:00	8853	164.9687	5/13/2048 0:00	8899	165.0216	6/28/2048 0:00	8945	165.0742	8/13/2048 0:00	8991	165.1265
3/29/2048 0:00	8854	164.9699	5/14/2048 0:00	8900	165.0228	6/29/2048 0:00	8946	165.0753	8/14/2048 0:00	8992	165.1277
3/30/2048 0:00	8855	164.971	5/15/2048 0:00	8901	165.0239	6/30/2048 0:00	8947	165.0765	8/15/2048 0:00	8993	165.1288
3/31/2048 0:00	8856	164.9722	5/16/2048 0:00	8902	165.025	7/1/2048 0:00	8948	165.0776	8/16/2048 0:00	8994	165.1299
4/1/2048 0:00	8857	164.9734	5/17/2048 0:00	8903	165.0262	7/2/2048 0:00	8949	165.0788	8/17/2048 0:00	8995	165.1311
4/2/2048 0:00	8858	164.9745	5/18/2048 0:00	8904	165.0273	7/3/2048 0:00	8950	165.0799	8/18/2048 0:00	8996	165.1322
4/3/2048 0:00	8859	164.9757	5/19/2048 0:00	8905	165.0285	7/4/2048 0:00	8951	165.081	8/19/2048 0:00	8997	165.1333
4/4/2048 0:00	8860	164.9768	5/20/2048 0:00	8906	165.0296	7/5/2048 0:00	8952	165.0822	8/20/2048 0:00	8998	165.1345
4/5/2048 0:00	8861	164.978	5/21/2048 0:00	8907	165.0308	7/6/2048 0:00	8953	165.0833	8/21/2048 0:00	8999	165.1356
4/6/2048 0:00	8862	164.9791	5/22/2048 0:00	8908	165.0319	7/7/2048 0:00	8954	165.0845	8/22/2048 0:00	9000	165.1367
4/7/2048 0:00	8863	164.9803	5/23/2048 0:00	8909	165.0331	7/8/2048 0:00	8955	165.0856	8/23/2048 0:00	9001	165.1379
4/8/2048 0:00	8864	164.9814	5/24/2048 0:00	8910	165.0342	7/9/2048 0:00	8956	165.0867	8/24/2048 0:00	9002	165.139
4/9/2048 0:00	8865	164.9826	5/25/2048 0:00	8911	165.0354	7/10/2048 0:00	8957	165.0879	8/25/2048 0:00	9003	165.1401

8/26/2048 0:00	9004	165.1413	10/11/2048 0:00	9050	165.1932	11/26/2048 0:00	9096	165.245	1/11/2049 0:00	9142	165.2964
8/27/2048 0:00	9005	165.1424	10/12/2048 0:00	9051	165.1944	11/27/2048 0:00	9097	165.2461	1/12/2049 0:00	9143	165.2975
8/28/2048 0:00	9006	165.1435	10/13/2048 0:00	9052	165.1955	11/28/2048 0:00	9098	165.2472	1/13/2049 0:00	9144	165.2987
8/29/2048 0:00	9007	165.1447	10/14/2048 0:00	9053	165.1966	11/29/2048 0:00	9099	165.2483	1/14/2049 0:00	9145	165.2998
8/30/2048 0:00	9008	165.1458	10/15/2048 0:00	9054	165.1978	11/30/2048 0:00	9100	165.2494	1/15/2049 0:00	9146	165.3009
8/31/2048 0:00	9009	165.1469	10/16/2048 0:00	9055	165.1989	12/1/2048 0:00	9101	165.2506	1/16/2049 0:00	9147	165.302
9/1/2048 0:00	9010	165.1481	10/17/2048 0:00	9056	165.2	12/2/2048 0:00	9102	165.2517	1/17/2049 0:00	9148	165.3031
9/2/2048 0:00	9011	165.1492	10/18/2048 0:00	9057	165.2011	12/3/2048 0:00	9103	165.2528	1/18/2049 0:00	9149	165.3042
9/3/2048 0:00	9012	165.1503	10/19/2048 0:00	9058	165.2023	12/4/2048 0:00	9104	165.2539	1/19/2049 0:00	9150	165.3053
9/4/2048 0:00	9013	165.1515	10/20/2048 0:00	9059	165.2034	12/5/2048 0:00	9105	165.2551	1/20/2049 0:00	9151	165.3065
9/5/2048 0:00	9014	165.1526	10/21/2048 0:00	9060	165.2045	12/6/2048 0:00	9106	165.2562	1/21/2049 0:00	9152	165.3076
9/6/2048 0:00	9015	165.1537	10/22/2048 0:00	9061	165.2056	12/7/2048 0:00	9107	165.2573	1/22/2049 0:00	9153	165.3087
9/7/2048 0:00	9016	165.1549	10/23/2048 0:00	9062	165.2068	12/8/2048 0:00	9108	165.2584	1/23/2049 0:00	9154	165.3098
9/8/2048 0:00	9017	165.156	10/24/2048 0:00	9063	165.2079	12/9/2048 0:00	9109	165.2595	1/24/2049 0:00	9155	165.3109
9/9/2048 0:00	9018	165.1571	10/25/2048 0:00	9064	165.209	12/10/2048 0:00	9110	165.2607	1/25/2049 0:00	9156	165.312
9/10/2048 0:00	9019	165.1582	10/26/2048 0:00	9065	165.2101	12/11/2048 0:00	9111	165.2618	1/26/2049 0:00	9157	165.3131
9/11/2048 0:00	9020	165.1594	10/27/2048 0:00	9066	165.2113	12/12/2048 0:00	9112	165.2629	1/27/2049 0:00	9158	165.3143
9/12/2048 0:00	9021	165.1605	10/28/2048 0:00	9067	165.2124	12/13/2048 0:00	9113	165.264	1/28/2049 0:00	9159	165.3154
9/13/2048 0:00	9022	165.1616	10/29/2048 0:00	9068	165.2135	12/14/2048 0:00	9114	165.2651	1/29/2049 0:00	9160	165.3165
9/14/2048 0:00	9023	165.1628	10/30/2048 0:00	9069	165.2146	12/15/2048 0:00	9115	165.2662	1/30/2049 0:00	9161	165.3176
9/15/2048 0:00	9024	165.1639	10/31/2048 0:00	9070	165.2158	12/16/2048 0:00	9116	165.2674	1/31/2049 0:00	9162	165.3187
9/16/2048 0:00	9025	165.165	11/1/2048 0:00	9071	165.2169	12/17/2048 0:00	9117	165.2685	2/1/2049 0:00	9163	165.3198
9/17/2048 0:00	9026	165.1662	11/2/2048 0:00	9072	165.218	12/18/2048 0:00	9118	165.2696	2/2/2049 0:00	9164	165.3209
9/18/2048 0:00	9027	165.1673	11/3/2048 0:00	9073	165.2191	12/19/2048 0:00	9119	165.2707	2/3/2049 0:00	9165	165.3221
9/19/2048 0:00	9028	165.1684	11/4/2048 0:00	9074	165.2203	12/20/2048 0:00	9120	165.2718	2/4/2049 0:00	9166	165.3232
9/20/2048 0:00	9029	165.1695	11/5/2048 0:00	9075	165.2214	12/21/2048 0:00	9121	165.273	2/5/2049 0:00	9167	165.3243
9/21/2048 0:00	9030	165.1707	11/6/2048 0:00	9076	165.2225	12/22/2048 0:00	9122	165.2741	2/6/2049 0:00	9168	165.3254
9/22/2048 0:00	9031	165.1718	11/7/2048 0:00	9077	165.2236	12/23/2048 0:00	9123	165.2752	2/7/2049 0:00	9169	165.3265
9/23/2048 0:00	9032	165.1729	11/8/2048 0:00	9078	165.2248	12/24/2048 0:00	9124	165.2763	2/8/2049 0:00	9170	165.3276
9/24/2048 0:00	9033	165.1741	11/9/2048 0:00	9079	165.2259	12/25/2048 0:00	9125	165.2774	2/9/2049 0:00	9171	165.3287
9/25/2048 0:00	9034	165.1752	11/10/2048 0:00	9080	165.227	12/26/2048 0:00	9126	165.2786	2/10/2049 0:00	9172	165.3298
9/26/2048 0:00	9035	165.1763	11/11/2048 0:00	9081	165.2281	12/27/2048 0:00	9127	165.2797	2/11/2049 0:00	9173	165.331
9/27/2048 0:00	9036	165.1775	11/12/2048 0:00	9082	165.2293	12/28/2048 0:00	9128	165.2808	2/12/2049 0:00	9174	165.3321
9/28/2048 0:00	9037	165.1786	11/13/2048 0:00	9083	165.2304	12/29/2048 0:00	9129	165.2819	2/13/2049 0:00	9175	165.3332
9/29/2048 0:00	9038	165.1797	11/14/2048 0:00	9084	165.2315	12/30/2048 0:00	9130	165.283	2/14/2049 0:00	9176	165.3343
9/30/2048 0:00	9039	165.1808	11/15/2048 0:00	9085	165.2326	12/31/2048 0:00	9131	165.2841	2/15/2049 0:00	9177	165.3354
10/1/2048 0:00	9040	165.182	11/16/2048 0:00	9086	165.2337	1/1/2049 0:00	9132	165.2853	2/16/2049 0:00	9178	165.3365
10/2/2048 0:00	9041	165.1831	11/17/2048 0:00	9087	165.2349	1/2/2049 0:00	9133	165.2864	2/17/2049 0:00	9179	165.3376
10/3/2048 0:00	9042	165.1842	11/18/2048 0:00	9088	165.236	1/3/2049 0:00	9134	165.2875	2/18/2049 0:00	9180	165.3387
10/4/2048 0:00	9043	165.1854	11/19/2048 0:00	9089	165.2371	1/4/2049 0:00	9135	165.2886	2/19/2049 0:00	9181	165.3398
10/5/2048 0:00	9044	165.1865	11/20/2048 0:00	9090	165.2382	1/5/2049 0:00	9136	165.2897	2/20/2049 0:00	9182	165.341
10/6/2048 0:00	9045	165.1876	11/21/2048 0:00	9091	165.2394	1/6/2049 0:00	9137	165.2908	2/21/2049 0:00	9183	165.3421
10/7/2048 0:00	9046	165.1887	11/22/2048 0:00	9092	165.2405	1/7/2049 0:00	9138	165.292	2/22/2049 0:00	9184	165.3432
10/8/2048 0:00	9047	165.1899	11/23/2048 0:00	9093	165.2416	1/8/2049 0:00	9139	165.2931	2/23/2049 0:00	9185	165.3443
10/9/2048 0:00	9048	165.191	11/24/2048 0:00	9094	165.2427	1/9/2049 0:00	9140	165.2942	2/24/2049 0:00	9186	165.3454
10/10/2048 0:00	9049	165.1921	11/25/2048 0:00	9095	165.2438	1/10/2049 0:00	9141	165.2953	2/25/2049 0:00	9187	165.3465

2/26/2049 0:00	9188	165.3476	4/13/2049 0:00	9234	165.3986	5/29/2049 0:00	9280	165.4493	7/14/2049 0:00	9326	165.4997
2/27/2049 0:00	9189	165.3487	4/14/2049 0:00	9235	165.3997	5/30/2049 0:00	9281	165.4504	7/15/2049 0:00	9327	165.5008
2/28/2049 0:00	9190	165.3498	4/15/2049 0:00	9236	165.4008	5/31/2049 0:00	9282	165.4515	7/16/2049 0:00	9328	165.5019
3/1/2049 0:00	9191	165.351	4/16/2049 0:00	9237	165.4019	6/1/2049 0:00	9283	165.4526	7/17/2049 0:00	9329	165.503
3/2/2049 0:00	9192	165.3521	4/17/2049 0:00	9238	165.403	6/2/2049 0:00	9284	165.4537	7/18/2049 0:00	9330	165.5041
3/3/2049 0:00	9193	165.3532	4/18/2049 0:00	9239	165.4041	6/3/2049 0:00	9285	165.4548	7/19/2049 0:00	9331	165.5052
3/4/2049 0:00	9194	165.3543	4/19/2049 0:00	9240	165.4052	6/4/2049 0:00	9286	165.4558	7/20/2049 0:00	9332	165.5063
3/5/2049 0:00	9195	165.3554	4/20/2049 0:00	9241	165.4063	6/5/2049 0:00	9287	165.4569	7/21/2049 0:00	9333	165.5074
3/6/2049 0:00	9196	165.3565	4/21/2049 0:00	9242	165.4074	6/6/2049 0:00	9288	165.458	7/22/2049 0:00	9334	165.5084
3/7/2049 0:00	9197	165.3576	4/22/2049 0:00	9243	165.4085	6/7/2049 0:00	9289	165.4591	7/23/2049 0:00	9335	165.5095
3/8/2049 0:00	9198	165.3587	4/23/2049 0:00	9244	165.4096	6/8/2049 0:00	9290	165.4602	7/24/2049 0:00	9336	165.5106
3/9/2049 0:00	9199	165.3598	4/24/2049 0:00	9245	165.4107	6/9/2049 0:00	9291	165.4613	7/25/2049 0:00	9337	165.5117
3/10/2049 0:00	9200	165.3609	4/25/2049 0:00	9246	165.4118	6/10/2049 0:00	9292	165.4624	7/26/2049 0:00	9338	165.5128
3/11/2049 0:00	9201	165.362	4/26/2049 0:00	9247	165.4129	6/11/2049 0:00	9293	165.4635	7/27/2049 0:00	9339	165.5139
3/12/2049 0:00	9202	165.3632	4/27/2049 0:00	9248	165.414	6/12/2049 0:00	9294	165.4646	7/28/2049 0:00	9340	165.515
3/13/2049 0:00	9203	165.3643	4/28/2049 0:00	9249	165.4151	6/13/2049 0:00	9295	165.4657	7/29/2049 0:00	9341	165.5161
3/14/2049 0:00	9204	165.3654	4/29/2049 0:00	9250	165.4162	6/14/2049 0:00	9296	165.4668	7/30/2049 0:00	9342	165.5172
3/15/2049 0:00	9205	165.3665	4/30/2049 0:00	9251	165.4173	6/15/2049 0:00	9297	165.4679	7/31/2049 0:00	9343	165.5183
3/16/2049 0:00	9206	165.3676	5/1/2049 0:00	9252	165.4184	6/16/2049 0:00	9298	165.469	8/1/2049 0:00	9344	165.5194
3/17/2049 0:00	9207	165.3687	5/2/2049 0:00	9253	165.4195	6/17/2049 0:00	9299	165.4701	8/2/2049 0:00	9345	165.5205
3/18/2049 0:00	9208	165.3698	5/3/2049 0:00	9254	165.4206	6/18/2049 0:00	9300	165.4712	8/3/2049 0:00	9346	165.5215
3/19/2049 0:00	9209	165.3709	5/4/2049 0:00	9255	165.4217	6/19/2049 0:00	9301	165.4723	8/4/2049 0:00	9347	165.5226
3/20/2049 0:00	9210	165.372	5/5/2049 0:00	9256	165.4228	6/20/2049 0:00	9302	165.4734	8/5/2049 0:00	9348	165.5237
3/21/2049 0:00	9211	165.3731	5/6/2049 0:00	9257	165.4239	6/21/2049 0:00	9303	165.4745	8/6/2049 0:00	9349	165.5248
3/22/2049 0:00	9212	165.3742	5/7/2049 0:00	9258	165.425	6/22/2049 0:00	9304	165.4756	8/7/2049 0:00	9350	165.5259
3/23/2049 0:00	9213	165.3753	5/8/2049 0:00	9259	165.4261	6/23/2049 0:00	9305	165.4767	8/8/2049 0:00	9351	165.527
3/24/2049 0:00	9214	165.3764	5/9/2049 0:00	9260	165.4272	6/24/2049 0:00	9306	165.4778	8/9/2049 0:00	9352	165.5281
3/25/2049 0:00	9215	165.3776	5/10/2049 0:00	9261	165.4283	6/25/2049 0:00	9307	165.4789	8/10/2049 0:00	9353	165.5292
3/26/2049 0:00	9216	165.3787	5/11/2049 0:00	9262	165.4295	6/26/2049 0:00	9308	165.48	8/11/2049 0:00	9354	165.5303
3/27/2049 0:00	9217	165.3798	5/12/2049 0:00	9263	165.4306	6/27/2049 0:00	9309	165.4811	8/12/2049 0:00	9355	165.5314
3/28/2049 0:00	9218	165.3809	5/13/2049 0:00	9264	165.4317	6/28/2049 0:00	9310	165.4822	8/13/2049 0:00	9356	165.5325
3/29/2049 0:00	9219	165.382	5/14/2049 0:00	9265	165.4328	6/29/2049 0:00	9311	165.4833	8/14/2049 0:00	9357	165.5335
3/30/2049 0:00	9220	165.3831	5/15/2049 0:00	9266	165.4339	6/30/2049 0:00	9312	165.4844	8/15/2049 0:00	9358	165.5346
3/31/2049 0:00	9221	165.3842	5/16/2049 0:00	9267	165.435	7/1/2049 0:00	9313	165.4855	8/16/2049 0:00	9359	165.5357
4/1/2049 0:00	9222	165.3853	5/17/2049 0:00	9268	165.4361	7/2/2049 0:00	9314	165.4866	8/17/2049 0:00	9360	165.5368
4/2/2049 0:00	9223	165.3864	5/18/2049 0:00	9269	165.4372	7/3/2049 0:00	9315	165.4877	8/18/2049 0:00	9361	165.5379
4/3/2049 0:00	9224	165.3875	5/19/2049 0:00	9270	165.4383	7/4/2049 0:00	9316	165.4888	8/19/2049 0:00	9362	165.539
4/4/2049 0:00	9225	165.3886	5/20/2049 0:00	9271	165.4394	7/5/2049 0:00	9317	165.4898	8/20/2049 0:00	9363	165.5401
4/5/2049 0:00	9226	165.3897	5/21/2049 0:00	9272	165.4405	7/6/2049 0:00	9318	165.4909	8/21/2049 0:00	9364	165.5412
4/6/2049 0:00	9227	165.3908	5/22/2049 0:00	9273	165.4416	7/7/2049 0:00	9319	165.492	8/22/2049 0:00	9365	165.5423
4/7/2049 0:00	9228	165.3919	5/23/2049 0:00	9274	165.4427	7/8/2049 0:00	9320	165.4931	8/23/2049 0:00	9366	165.5434
4/8/2049 0:00	9229	165.393	5/24/2049 0:00	9275	165.4438	7/9/2049 0:00	9321	165.4942	8/24/2049 0:00	9367	165.5444
4/9/2049 0:00	9230	165.3941	5/25/2049 0:00	9276	165.4449	7/10/2049 0:00	9322	165.4953	8/25/2049 0:00	9368	165.5455
4/10/2049 0:00	9231	165.3953	5/26/2049 0:00	9277	165.446	7/11/2049 0:00	9323	165.4964	8/26/2049 0:00	9369	165.5466
4/11/2049 0:00	9232	165.3964	5/27/2049 0:00	9278	165.4471	7/12/2049 0:00	9324	165.4975	8/27/2049 0:00	9370	165.5477
4/12/2049 0:00	9233	165.3975	5/28/2049 0:00	9279	165.4482	7/13/2049 0:00	9325	165.4986	8/28/2049 0:00	9371	165.5488

8/29/2049 0:00	9372	165.5499	10/14/2049 0:00	9418	165.5998	11/29/2049 0:00	9464	165.6495	1/14/2050 0:00	9510	165.699
8/30/2049 0:00	9373	165.551	10/15/2049 0:00	9419	165.6009	11/30/2049 0:00	9465	165.6506	1/15/2050 0:00	9511	165.7001
8/31/2049 0:00	9374	165.5521	10/16/2049 0:00	9420	165.602	12/1/2049 0:00	9466	165.6517	1/16/2050 0:00	9512	165.7011
9/1/2049 0:00	9375	165.5532	10/17/2049 0:00	9421	165.6031	12/2/2049 0:00	9467	165.6528	1/17/2050 0:00	9513	165.7022
9/2/2049 0:00	9376	165.5542	10/18/2049 0:00	9422	165.6042	12/3/2049 0:00	9468	165.6538	1/18/2050 0:00	9514	165.7033
9/3/2049 0:00	9377	165.5553	10/19/2049 0:00	9423	165.6052	12/4/2049 0:00	9469	165.6549	1/19/2050 0:00	9515	165.7044
9/4/2049 0:00	9378	165.5564	10/20/2049 0:00	9424	165.6063	12/5/2049 0:00	9470	165.656	1/20/2050 0:00	9516	165.7054
9/5/2049 0:00	9379	165.5575	10/21/2049 0:00	9425	165.6074	12/6/2049 0:00	9471	165.6571	1/21/2050 0:00	9517	165.7065
9/6/2049 0:00	9380	165.5586	10/22/2049 0:00	9426	165.6085	12/7/2049 0:00	9472	165.6582	1/22/2050 0:00	9518	165.7076
9/7/2049 0:00	9381	165.5597	10/23/2049 0:00	9427	165.6096	12/8/2049 0:00	9473	165.6592	1/23/2050 0:00	9519	165.7086
9/8/2049 0:00	9382	165.5608	10/24/2049 0:00	9428	165.6107	12/9/2049 0:00	9474	165.6603	1/24/2050 0:00	9520	165.7097
9/9/2049 0:00	9383	165.5619	10/25/2049 0:00	9429	165.6117	12/10/2049 0:00	9475	165.6614	1/25/2050 0:00	9521	165.7108
9/10/2049 0:00	9384	165.5629	10/26/2049 0:00	9430	165.6128	12/11/2049 0:00	9476	165.6625	1/26/2050 0:00	9522	165.7119
9/11/2049 0:00	9385	165.564	10/27/2049 0:00	9431	165.6139	12/12/2049 0:00	9477	165.6635	1/27/2050 0:00	9523	165.7129
9/12/2049 0:00	9386	165.5651	10/28/2049 0:00	9432	165.615	12/13/2049 0:00	9478	165.6646	1/28/2050 0:00	9524	165.714
9/13/2049 0:00	9387	165.5662	10/29/2049 0:00	9433	165.6161	12/14/2049 0:00	9479	165.6657	1/29/2050 0:00	9525	165.7151
9/14/2049 0:00	9388	165.5673	10/30/2049 0:00	9434	165.6172	12/15/2049 0:00	9480	165.6668	1/30/2050 0:00	9526	165.7161
9/15/2049 0:00	9389	165.5684	10/31/2049 0:00	9435	165.6182	12/16/2049 0:00	9481	165.6678	1/31/2050 0:00	9527	165.7172
9/16/2049 0:00	9390	165.5695	11/1/2049 0:00	9436	165.6193	12/17/2049 0:00	9482	165.6689	2/1/2050 0:00	9528	165.7183
9/17/2049 0:00	9391	165.5705	11/2/2049 0:00	9437	165.6204	12/18/2049 0:00	9483	165.67	2/2/2050 0:00	9529	165.7194
9/18/2049 0:00	9392	165.5716	11/3/2049 0:00	9438	165.6215	12/19/2049 0:00	9484	165.6711	2/3/2050 0:00	9530	165.7204
9/19/2049 0:00	9393	165.5727	11/4/2049 0:00	9439	165.6226	12/20/2049 0:00	9485	165.6721	2/4/2050 0:00	9531	165.7215
9/20/2049 0:00	9394	165.5738	11/5/2049 0:00	9440	165.6236	12/21/2049 0:00	9486	165.6732	2/5/2050 0:00	9532	165.7226
9/21/2049 0:00	9395	165.5749	11/6/2049 0:00	9441	165.6247	12/22/2049 0:00	9487	165.6743	2/6/2050 0:00	9533	165.7236
9/22/2049 0:00	9396	165.576	11/7/2049 0:00	9442	165.6258	12/23/2049 0:00	9488	165.6754	2/7/2050 0:00	9534	165.7247
9/23/2049 0:00	9397	165.5771	11/8/2049 0:00	9443	165.6269	12/24/2049 0:00	9489	165.6764	2/8/2050 0:00	9535	165.7258
9/24/2049 0:00	9398	165.5781	11/9/2049 0:00	9444	165.628	12/25/2049 0:00	9490	165.6775	2/9/2050 0:00	9536	165.7269
9/25/2049 0:00	9399	165.5792	11/10/2049 0:00	9445	165.629	12/26/2049 0:00	9491	165.6786	2/10/2050 0:00	9537	165.7279
9/26/2049 0:00	9400	165.5803	11/11/2049 0:00	9446	165.6301	12/27/2049 0:00	9492	165.6797	2/11/2050 0:00	9538	165.729
9/27/2049 0:00	9401	165.5814	11/12/2049 0:00	9447	165.6312	12/28/2049 0:00	9493	165.6807	2/12/2050 0:00	9539	165.7301
9/28/2049 0:00	9402	165.5825	11/13/2049 0:00	9448	165.6323	12/29/2049 0:00	9494	165.6818	2/13/2050 0:00	9540	165.7311
9/29/2049 0:00	9403	165.5836	11/14/2049 0:00	9449	165.6334	12/30/2049 0:00	9495	165.6829	2/14/2050 0:00	9541	165.7322
9/30/2049 0:00	9404	165.5847	11/15/2049 0:00	9450	165.6344	12/31/2049 0:00	9496	165.684	2/15/2050 0:00	9542	165.7333
10/1/2049 0:00	9405	165.5857	11/16/2049 0:00	9451	165.6355	1/1/2050 0:00	9497	165.685	2/16/2050 0:00	9543	165.7343
10/2/2049 0:00	9406	165.5868	11/17/2049 0:00	9452	165.6366	1/2/2050 0:00	9498	165.6861	2/17/2050 0:00	9544	165.7354
10/3/2049 0:00	9407	165.5879	11/18/2049 0:00	9453	165.6377	1/3/2050 0:00	9499	165.6872	2/18/2050 0:00	9545	165.7365
10/4/2049 0:00	9408	165.589	11/19/2049 0:00	9454	165.6388	1/4/2050 0:00	9500	165.6883	2/19/2050 0:00	9546	165.7375
10/5/2049 0:00	9409	165.5901	11/20/2049 0:00	9455	165.6398	1/5/2050 0:00	9501	165.6893	2/20/2050 0:00	9547	165.7386
10/6/2049 0:00	9410	165.5912	11/21/2049 0:00	9456	165.6409	1/6/2050 0:00	9502	165.6904	2/21/2050 0:00	9548	165.7397
10/7/2049 0:00	9411	165.5923	11/22/2049 0:00	9457	165.642	1/7/2050 0:00	9503	165.6915	2/22/2050 0:00	9549	165.7407
10/8/2049 0:00	9412	165.5933	11/23/2049 0:00	9458	165.6431	1/8/2050 0:00	9504	165.6926	2/23/2050 0:00	9550	165.7418
10/9/2049 0:00	9413	165.5944	11/24/2049 0:00	9459	165.6441	1/9/2050 0:00	9505	165.6936	2/24/2050 0:00	9551	165.7429
10/10/2049 0:00	9414	165.5955	11/25/2049 0:00	9460	165.6452	1/10/2050 0:00	9506	165.6947	2/25/2050 0:00	9552	165.744
10/11/2049 0:00	9415	165.5966	11/26/2049 0:00	9461	165.6463	1/11/2050 0:00	9507	165.6958	2/26/2050 0:00	9553	165.745
10/12/2049 0:00	9416	165.5977	11/27/2049 0:00	9462	165.6474	1/12/2050 0:00	9508	165.6969	2/27/2050 0:00	9554	165.7461
10/13/2049 0:00	9417	165.5988	11/28/2049 0:00	9463	165.6485	1/13/2050 0:00	9509	165.6979	2/28/2050 0:00	9555	165.7472

3/1/2050 0:00	9556	165.7482	4/16/2050 0:00	9602	165.7972	6/1/2050 0:00	9648	165.846	7/17/2050 0:00	9694	165.8945
3/2/2050 0:00	9557	165.7493	4/17/2050 0:00	9603	165.7983	6/2/2050 0:00	9649	165.847	7/18/2050 0:00	9695	165.8955
3/3/2050 0:00	9558	165.7504	4/18/2050 0:00	9604	165.7993	6/3/2050 0:00	9650	165.8481	7/19/2050 0:00	9696	165.8966
3/4/2050 0:00	9559	165.7514	4/19/2050 0:00	9605	165.8004	6/4/2050 0:00	9651	165.8491	7/20/2050 0:00	9697	165.8976
3/5/2050 0:00	9560	165.7525	4/20/2050 0:00	9606	165.8015	6/5/2050 0:00	9652	165.8502	7/21/2050 0:00	9698	165.8987
3/6/2050 0:00	9561	165.7536	4/21/2050 0:00	9607	165.8025	6/6/2050 0:00	9653	165.8513	7/22/2050 0:00	9699	165.8997
3/7/2050 0:00	9562	165.7546	4/22/2050 0:00	9608	165.8036	6/7/2050 0:00	9654	165.8523	7/23/2050 0:00	9700	165.9008
3/8/2050 0:00	9563	165.7557	4/23/2050 0:00	9609	165.8046	6/8/2050 0:00	9655	165.8534	7/24/2050 0:00	9701	165.9019
3/9/2050 0:00	9564	165.7568	4/24/2050 0:00	9610	165.8057	6/9/2050 0:00	9656	165.8544	7/25/2050 0:00	9702	165.9029
3/10/2050 0:00	9565	165.7578	4/25/2050 0:00	9611	165.8068	6/10/2050 0:00	9657	165.8555	7/26/2050 0:00	9703	165.904
3/11/2050 0:00	9566	165.7589	4/26/2050 0:00	9612	165.8078	6/11/2050 0:00	9658	165.8565	7/27/2050 0:00	9704	165.905
3/12/2050 0:00	9567	165.76	4/27/2050 0:00	9613	165.8089	6/12/2050 0:00	9659	165.8576	7/28/2050 0:00	9705	165.9061
3/13/2050 0:00	9568	165.761	4/28/2050 0:00	9614	165.81	6/13/2050 0:00	9660	165.8586	7/29/2050 0:00	9706	165.9071
3/14/2050 0:00	9569	165.7621	4/29/2050 0:00	9615	165.811	6/14/2050 0:00	9661	165.8597	7/30/2050 0:00	9707	165.9082
3/15/2050 0:00	9570	165.7632	4/30/2050 0:00	9616	165.8121	6/15/2050 0:00	9662	165.8608	7/31/2050 0:00	9708	165.9092
3/16/2050 0:00	9571	165.7642	5/1/2050 0:00	9617	165.8131	6/16/2050 0:00	9663	165.8618	8/1/2050 0:00	9709	165.9103
3/17/2050 0:00	9572	165.7653	5/2/2050 0:00	9618	165.8142	6/17/2050 0:00	9664	165.8629	8/2/2050 0:00	9710	165.9113
3/18/2050 0:00	9573	165.7664	5/3/2050 0:00	9619	165.8153	6/18/2050 0:00	9665	165.8639	8/3/2050 0:00	9711	165.9124
3/19/2050 0:00	9574	165.7674	5/4/2050 0:00	9620	165.8163	6/19/2050 0:00	9666	165.865	8/4/2050 0:00	9712	165.9134
3/20/2050 0:00	9575	165.7685	5/5/2050 0:00	9621	165.8174	6/20/2050 0:00	9667	165.866	8/5/2050 0:00	9713	165.9145
3/21/2050 0:00	9576	165.7696	5/6/2050 0:00	9622	165.8184	6/21/2050 0:00	9668	165.8671	8/6/2050 0:00	9714	165.9155
3/22/2050 0:00	9577	165.7706	5/7/2050 0:00	9623	165.8195	6/22/2050 0:00	9669	165.8681	8/7/2050 0:00	9715	165.9166
3/23/2050 0:00	9578	165.7717	5/8/2050 0:00	9624	165.8206	6/23/2050 0:00	9670	165.8692	8/8/2050 0:00	9716	165.9176
3/24/2050 0:00	9579	165.7727	5/9/2050 0:00	9625	165.8216	6/24/2050 0:00	9671	165.8703	8/9/2050 0:00	9717	165.9187
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3/26/2050 0:00	9581	165.7749	5/11/2050 0:00	9627	165.8237	6/26/2050 0:00	9673	165.8724	8/11/2050 0:00	9719	165.9208
3/27/2050 0:00	9582	165.7759	5/12/2050 0:00	9628	165.8248	6/27/2050 0:00	9674	165.8734	8/12/2050 0:00	9720	165.9218
3/28/2050 0:00	9583	165.777	5/13/2050 0:00	9629	165.8259	6/28/2050 0:00	9675	165.8745	8/13/2050 0:00	9721	165.9229
3/29/2050 0:00	9584	165.7781	5/14/2050 0:00	9630	165.8269	6/29/2050 0:00	9676	165.8755	8/14/2050 0:00	9722	165.9239
3/30/2050 0:00	9585	165.7791	5/15/2050 0:00	9631	165.828	6/30/2050 0:00	9677	165.8766	8/15/2050 0:00	9723	165.925
3/31/2050 0:00	9586	165.7802	5/16/2050 0:00	9632	165.829	7/1/2050 0:00	9678	165.8776	8/16/2050 0:00	9724	165.926
4/1/2050 0:00	9587	165.7813	5/17/2050 0:00	9633	165.8301	7/2/2050 0:00	9679	165.8787	8/17/2050 0:00	9725	165.9271
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4/3/2050 0:00	9589	165.7834	5/19/2050 0:00	9635	165.8322	7/4/2050 0:00	9681	165.8808	8/19/2050 0:00	9727	165.9292
4/4/2050 0:00	9590	165.7845	5/20/2050 0:00	9636	165.8333	7/5/2050 0:00	9682	165.8819	8/20/2050 0:00	9728	165.9302
4/5/2050 0:00	9591	165.7855	5/21/2050 0:00	9637	165.8343	7/6/2050 0:00	9683	165.8829	8/21/2050 0:00	9729	165.9313
4/6/2050 0:00	9592	165.7866	5/22/2050 0:00	9638	165.8354	7/7/2050 0:00	9684	165.884	8/22/2050 0:00	9730	165.9323
4/7/2050 0:00	9593	165.7876	5/23/2050 0:00	9639	165.8364	7/8/2050 0:00	9685	165.885	8/23/2050 0:00	9731	165.9333
4/8/2050 0:00	9594	165.7887	5/24/2050 0:00	9640	165.8375	7/9/2050 0:00	9686	165.8861	8/24/2050 0:00	9732	165.9344
4/9/2050 0:00	9595	165.7898	5/25/2050 0:00	9641	165.8386	7/10/2050 0:00	9687	165.8871	8/25/2050 0:00	9733	165.9354
4/10/2050 0:00	9596	165.7908	5/26/2050 0:00	9642	165.8396	7/11/2050 0:00	9688	165.8882	8/26/2050 0:00	9734	165.9365
4/11/2050 0:00	9597	165.7919	5/27/2050 0:00	9643	165.8407	7/12/2050 0:00	9689	165.8892	8/27/2050 0:00	9735	165.9375
4/12/2050 0:00	9598	165.793	5/28/2050 0:00	9644	165.8417	7/13/2050 0:00	9690	165.8903	8/28/2050 0:00	9736	165.9386
4/13/2050 0:00	9599	165.794	5/29/2050 0:00	9645	165.8428	7/14/2050 0:00	9691	165.8913	8/29/2050 0:00	9737	165.9396
4/14/2050 0:00	9600	165.7951	5/30/2050 0:00	9646	165.8439	7/15/2050 0:00	9692	165.8924	8/30/2050 0:00	9738	165.9407
4/15/2050 0:00	9601	165.7961	5/31/2050 0:00	9647	165.8449	7/16/2050 0:00	9693	165.8934	8/31/2050 0:00	9739	165.9417

9/1/2050 0:00	9740	165.9428	10/17/2050 0:00	9786	165.9908	12/2/2050 0:00	9832	166.0387	1/17/2051 0:00	9878	166.0863
9/2/2050 0:00	9741	165.9438	10/18/2050 0:00	9787	165.9919	12/3/2050 0:00	9833	166.0397	1/18/2051 0:00	9879	166.0873
9/3/2050 0:00	9742	165.9449	10/19/2050 0:00	9788	165.9929	12/4/2050 0:00	9834	166.0408	1/19/2051 0:00	9880	166.0884
9/4/2050 0:00	9743	165.9459	10/20/2050 0:00	9789	165.994	12/5/2050 0:00	9835	166.0418	1/20/2051 0:00	9881	166.0894
9/5/2050 0:00	9744	165.947	10/21/2050 0:00	9790	165.995	12/6/2050 0:00	9836	166.0428	1/21/2051 0:00	9882	166.0904
9/6/2050 0:00	9745	165.948	10/22/2050 0:00	9791	165.9961	12/7/2050 0:00	9837	166.0439	1/22/2051 0:00	9883	166.0915
9/7/2050 0:00	9746	165.9491	10/23/2050 0:00	9792	165.9971	12/8/2050 0:00	9838	166.0449	1/23/2051 0:00	9884	166.0925
9/8/2050 0:00	9747	165.9501	10/24/2050 0:00	9793	165.9981	12/9/2050 0:00	9839	166.0459	1/24/2051 0:00	9885	166.0935
9/9/2050 0:00	9748	165.9512	10/25/2050 0:00	9794	165.9992	12/10/2050 0:00	9840	166.047	1/25/2051 0:00	9886	166.0946
9/10/2050 0:00	9749	165.9522	10/26/2050 0:00	9795	166.0002	12/11/2050 0:00	9841	166.048	1/26/2051 0:00	9887	166.0956
9/11/2050 0:00	9750	165.9532	10/27/2050 0:00	9796	166.0013	12/12/2050 0:00	9842	166.0491	1/27/2051 0:00	9888	166.0966
9/12/2050 0:00	9751	165.9543	10/28/2050 0:00	9797	166.0023	12/13/2050 0:00	9843	166.0501	1/28/2051 0:00	9889	166.0977
9/13/2050 0:00	9752	165.9553	10/29/2050 0:00	9798	166.0033	12/14/2050 0:00	9844	166.0511	1/29/2051 0:00	9890	166.0987
9/14/2050 0:00	9753	165.9564	10/30/2050 0:00	9799	166.0044	12/15/2050 0:00	9845	166.0522	1/30/2051 0:00	9891	166.0997
9/15/2050 0:00	9754	165.9574	10/31/2050 0:00	9800	166.0054	12/16/2050 0:00	9846	166.0532	1/31/2051 0:00	9892	166.1007
9/16/2050 0:00	9755	165.9585	11/1/2050 0:00	9801	166.0065	12/17/2050 0:00	9847	166.0542	2/1/2051 0:00	9893	166.1018
9/17/2050 0:00	9756	165.9595	11/2/2050 0:00	9802	166.0075	12/18/2050 0:00	9848	166.0553	2/2/2051 0:00	9894	166.1028
9/18/2050 0:00	9757	165.9606	11/3/2050 0:00	9803	166.0085	12/19/2050 0:00	9849	166.0563	2/3/2051 0:00	9895	166.1038
9/19/2050 0:00	9758	165.9616	11/4/2050 0:00	9804	166.0096	12/20/2050 0:00	9850	166.0573	2/4/2051 0:00	9896	166.1049
9/20/2050 0:00	9759	165.9627	11/5/2050 0:00	9805	166.0106	12/21/2050 0:00	9851	166.0584	2/5/2051 0:00	9897	166.1059
9/21/2050 0:00	9760	165.9637	11/6/2050 0:00	9806	166.0117	12/22/2050 0:00	9852	166.0594	2/6/2051 0:00	9898	166.1069
9/22/2050 0:00	9761	165.9647	11/7/2050 0:00	9807	166.0127	12/23/2050 0:00	9853	166.0604	2/7/2051 0:00	9899	166.108
9/23/2050 0:00	9762	165.9658	11/8/2050 0:00	9808	166.0138	12/24/2050 0:00	9854	166.0615	2/8/2051 0:00	9900	166.109
9/24/2050 0:00	9763	165.9668	11/9/2050 0:00	9809	166.0148	12/25/2050 0:00	9855	166.0625	2/9/2051 0:00	9901	166.11
9/25/2050 0:00	9764	165.9679	11/10/2050 0:00	9810	166.0158	12/26/2050 0:00	9856	166.0636	2/10/2051 0:00	9902	166.1111
9/26/2050 0:00	9765	165.9689	11/11/2050 0:00	9811	166.0169	12/27/2050 0:00	9857	166.0646	2/11/2051 0:00	9903	166.1121
9/27/2050 0:00	9766	165.97	11/12/2050 0:00	9812	166.0179	12/28/2050 0:00	9858	166.0656	2/12/2051 0:00	9904	166.1131
9/28/2050 0:00	9767	165.971	11/13/2050 0:00	9813	166.019	12/29/2050 0:00	9859	166.0667	2/13/2051 0:00	9905	166.1141
9/29/2050 0:00	9768	165.9721	11/14/2050 0:00	9814	166.02	12/30/2050 0:00	9860	166.0677	2/14/2051 0:00	9906	166.1152
9/30/2050 0:00	9769	165.9731	11/15/2050 0:00	9815	166.021	12/31/2050 0:00	9861	166.0687	2/15/2051 0:00	9907	166.1162
10/1/2050 0:00	9770	165.9742	11/16/2050 0:00	9816	166.0221	1/1/2051 0:00	9862	166.0698	2/16/2051 0:00	9908	166.1172
10/2/2050 0:00	9771	165.9752	11/17/2050 0:00	9817	166.0231	1/2/2051 0:00	9863	166.0708	2/17/2051 0:00	9909	166.1183
10/3/2050 0:00	9772	165.9762	11/18/2050 0:00	9818	166.0241	1/3/2051 0:00	9864	166.0718	2/18/2051 0:00	9910	166.1193
10/4/2050 0:00	9773	165.9773	11/19/2050 0:00	9819	166.0252	1/4/2051 0:00	9865	166.0729	2/19/2051 0:00	9911	166.1203
10/5/2050 0:00	9774	165.9783	11/20/2050 0:00	9820	166.0262	1/5/2051 0:00	9866	166.0739	2/20/2051 0:00	9912	166.1214
10/6/2050 0:00	9775	165.9794	11/21/2050 0:00	9821	166.0273	1/6/2051 0:00	9867	166.0749	2/21/2051 0:00	9913	166.1224
10/7/2050 0:00	9776	165.9804	11/22/2050 0:00	9822	166.0283	1/7/2051 0:00	9868	166.076	2/22/2051 0:00	9914	166.1234
10/8/2050 0:00	9777	165.9815	11/23/2050 0:00	9823	166.0293	1/8/2051 0:00	9869	166.077	2/23/2051 0:00	9915	166.1244
10/9/2050 0:00	9778	165.9825	11/24/2050 0:00	9824	166.0304	1/9/2051 0:00	9870	166.078	2/24/2051 0:00	9916	166.1255
10/10/2050 0:00	9779	165.9835	11/25/2050 0:00	9825	166.0314	1/10/2051 0:00	9871	166.0791	2/25/2051 0:00	9917	166.1265
10/11/2050 0:00	9780	165.9846	11/26/2050 0:00	9826	166.0325	1/11/2051 0:00	9872	166.0801	2/26/2051 0:00	9918	166.1275
10/12/2050 0:00	9781	165.9856	11/27/2050 0:00	9827	166.0335	1/12/2051 0:00	9873	166.0811	2/27/2051 0:00	9919	166.1286
10/13/2050 0:00	9782	165.9867	11/28/2050 0:00	9828	166.0345	1/13/2051 0:00	9874	166.0822	2/28/2051 0:00	9920	166.1296
10/14/2050 0:00	9783	165.9877	11/29/2050 0:00	9829	166.0356	1/14/2051 0:00	9875	166.0832	3/1/2051 0:00	9921	166.1306
10/15/2050 0:00	9784	165.9888	11/30/2050 0:00	9830	166.0366	1/15/2051 0:00	9876	166.0842	3/2/2051 0:00	9922	166.1316
10/16/2050 0:00	9785	165.9898	12/1/2050 0:00	9831	166.0376	1/16/2051 0:00	9877	166.0853	3/3/2051 0:00	9923	166.1327

3/4/2051 0:00	9924	166.1337	4/19/2051 0:00	9970	166.1809	6/4/2051 0:00	10016	166.2278	7/20/2051 0:00	10062	166.2746
3/5/2051 0:00	9925	166.1347	4/20/2051 0:00	9971	166.1819	6/5/2051 0:00	10017	166.2288	7/21/2051 0:00	10063	166.2756
3/6/2051 0:00	9926	166.1357	4/21/2051 0:00	9972	166.1829	6/6/2051 0:00	10018	166.2299	7/22/2051 0:00	10064	166.2766
3/7/2051 0:00	9927	166.1368	4/22/2051 0:00	9973	166.1839	6/7/2051 0:00	10019	166.2309	7/23/2051 0:00	10065	166.2776
3/8/2051 0:00	9928	166.1378	4/23/2051 0:00	9974	166.185	6/8/2051 0:00	10020	166.2319	7/24/2051 0:00	10066	166.2786
3/9/2051 0:00	9929	166.1388	4/24/2051 0:00	9975	166.186	6/9/2051 0:00	10021	166.2329	7/25/2051 0:00	10067	166.2796
3/10/2051 0:00	9930	166.1399	4/25/2051 0:00	9976	166.187	6/10/2051 0:00	10022	166.2339	7/26/2051 0:00	10068	166.2807
3/11/2051 0:00	9931	166.1409	4/26/2051 0:00	9977	166.188	6/11/2051 0:00	10023	166.235	7/27/2051 0:00	10069	166.2817
3/12/2051 0:00	9932	166.1419	4/27/2051 0:00	9978	166.1891	6/12/2051 0:00	10024	166.236	7/28/2051 0:00	10070	166.2827
3/13/2051 0:00	9933	166.1429	4/28/2051 0:00	9979	166.1901	6/13/2051 0:00	10025	166.237	7/29/2051 0:00	10071	166.2837
3/14/2051 0:00	9934	166.144	4/29/2051 0:00	9980	166.1911	6/14/2051 0:00	10026	166.238	7/30/2051 0:00	10072	166.2847
3/15/2051 0:00	9935	166.145	4/30/2051 0:00	9981	166.1921	6/15/2051 0:00	10027	166.239	7/31/2051 0:00	10073	166.2857
3/16/2051 0:00	9936	166.146	5/1/2051 0:00	9982	166.1931	6/16/2051 0:00	10028	166.24	8/1/2051 0:00	10074	166.2867
3/17/2051 0:00	9937	166.147	5/2/2051 0:00	9983	166.1942	6/17/2051 0:00	10029	166.2411	8/2/2051 0:00	10075	166.2877
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3/20/2051 0:00	9940	166.1501	5/5/2051 0:00	9986	166.1972	6/20/2051 0:00	10032	166.2441	8/5/2051 0:00	10078	166.2908
3/21/2051 0:00	9941	166.1512	5/6/2051 0:00	9987	166.1982	6/21/2051 0:00	10033	166.2451	8/6/2051 0:00	10079	166.2918
3/22/2051 0:00	9942	166.1522	5/7/2051 0:00	9988	166.1993	6/22/2051 0:00	10034	166.2461	8/7/2051 0:00	10080	166.2928
3/23/2051 0:00	9943	166.1532	5/8/2051 0:00	9989	166.2003	6/23/2051 0:00	10035	166.2472	8/8/2051 0:00	10081	166.2938
3/24/2051 0:00	9944	166.1542	5/9/2051 0:00	9990	166.2013	6/24/2051 0:00	10036	166.2482	8/9/2051 0:00	10082	166.2948
3/25/2051 0:00	9945	166.1553	5/10/2051 0:00	9991	166.2023	6/25/2051 0:00	10037	166.2492	8/10/2051 0:00	10083	166.2958
3/26/2051 0:00	9946	166.1563	5/11/2051 0:00	9992	166.2034	6/26/2051 0:00	10038	166.2502	8/11/2051 0:00	10084	166.2969
3/27/2051 0:00	9947	166.1573	5/12/2051 0:00	9993	166.2044	6/27/2051 0:00	10039	166.2512	8/12/2051 0:00	10085	166.2979
3/28/2051 0:00	9948	166.1583	5/13/2051 0:00	9994	166.2054	6/28/2051 0:00	10040	166.2522	8/13/2051 0:00	10086	166.2989
3/29/2051 0:00	9949	166.1594	5/14/2051 0:00	9995	166.2064	6/29/2051 0:00	10041	166.2533	8/14/2051 0:00	10087	166.2999
3/30/2051 0:00	9950	166.1604	5/15/2051 0:00	9996	166.2074	6/30/2051 0:00	10042	166.2543	8/15/2051 0:00	10088	166.3009
3/31/2051 0:00	9951	166.1614	5/16/2051 0:00	9997	166.2085	7/1/2051 0:00	10043	166.2553	8/16/2051 0:00	10089	166.3019
4/1/2051 0:00	9952	166.1624	5/17/2051 0:00	9998	166.2095	7/2/2051 0:00	10044	166.2563	8/17/2051 0:00	10090	166.3029
4/2/2051 0:00	9953	166.1635	5/18/2051 0:00	9999	166.2105	7/3/2051 0:00	10045	166.2573	8/18/2051 0:00	10091	166.3039
4/3/2051 0:00	9954	166.1645	5/19/2051 0:00	10000	166.2115	7/4/2051 0:00	10046	166.2583	8/19/2051 0:00	10092	166.3049
4/4/2051 0:00	9955	166.1655	5/20/2051 0:00	10001	166.2125	7/5/2051 0:00	10047	166.2594	8/20/2051 0:00	10093	166.306
4/5/2051 0:00	9956	166.1665	5/21/2051 0:00	10002	166.2136	7/6/2051 0:00	10048	166.2604	8/21/2051 0:00	10094	166.307
4/6/2051 0:00	9957	166.1676	5/22/2051 0:00	10003	166.2146	7/7/2051 0:00	10049	166.2614	8/22/2051 0:00	10095	166.308
4/7/2051 0:00	9958	166.1686	5/23/2051 0:00	10004	166.2156	7/8/2051 0:00	10050	166.2624	8/23/2051 0:00	10096	166.309
4/8/2051 0:00	9959	166.1696	5/24/2051 0:00	10005	166.2166	7/9/2051 0:00	10051	166.2634	8/24/2051 0:00	10097	166.31
4/9/2051 0:00	9960	166.1706	5/25/2051 0:00	10006	166.2176	7/10/2051 0:00	10052	166.2644	8/25/2051 0:00	10098	166.311
4/10/2051 0:00	9961	166.1717	5/26/2051 0:00	10007	166.2187	7/11/2051 0:00	10053	166.2654	8/26/2051 0:00	10099	166.312
4/11/2051 0:00	9962	166.1727	5/27/2051 0:00	10008	166.2197	7/12/2051 0:00	10054	166.2665	8/27/2051 0:00	10100	166.313
4/12/2051 0:00	9963	166.1737	5/28/2051 0:00	10009	166.2207	7/13/2051 0:00	10055	166.2675	8/28/2051 0:00	10101	166.314
4/13/2051 0:00	9964	166.1747	5/29/2051 0:00	10010	166.2217	7/14/2051 0:00	10056	166.2685	8/29/2051 0:00	10102	166.315
4/14/2051 0:00	9965	166.1758	5/30/2051 0:00	10011	166.2227	7/15/2051 0:00	10057	166.2695	8/30/2051 0:00	10103	166.3161
4/15/2051 0:00	9966	166.1768	5/31/2051 0:00	10012	166.2238	7/16/2051 0:00	10058	166.2705	8/31/2051 0:00	10104	166.3171
4/16/2051 0:00	9967	166.1778	6/1/2051 0:00	10013	166.2248	7/17/2051 0:00	10059	166.2715	9/1/2051 0:00	10105	166.3181
4/17/2051 0:00	9968	166.1788	6/2/2051 0:00	10014	166.2258	7/18/2051 0:00	10060	166.2725	9/2/2051 0:00	10106	166.3191
4/18/2051 0:00	9969	166.1798	6/3/2051 0:00	10015	166.2268	7/19/2051 0:00	10061	166.2736	9/3/2051 0:00	10107	166.3201

9/4/2051 0:00	10108	166.3211	10/20/2051 0:00	10154	166.3674	12/5/2051 0:00	10200	166.4135	1/20/2052 0:00	10246	166.4594
9/5/2051 0:00	10109	166.3221	10/21/2051 0:00	10155	166.3684	12/6/2051 0:00	10201	166.4145	1/21/2052 0:00	10247	166.4604
9/6/2051 0:00	10110	166.3231	10/22/2051 0:00	10156	166.3694	12/7/2051 0:00	10202	166.4155	1/22/2052 0:00	10248	166.4614
9/7/2051 0:00	10111	166.3241	10/23/2051 0:00	10157	166.3704	12/8/2051 0:00	10203	166.4165	1/23/2052 0:00	10249	166.4624
9/8/2051 0:00	10112	166.3251	10/24/2051 0:00	10158	166.3714	12/9/2051 0:00	10204	166.4175	1/24/2052 0:00	10250	166.4634
9/9/2051 0:00	10113	166.3261	10/25/2051 0:00	10159	166.3724	12/10/2051 0:00	10205	166.4185	1/25/2052 0:00	10251	166.4644
9/10/2051 0:00	10114	166.3272	10/26/2051 0:00	10160	166.3734	12/11/2051 0:00	10206	166.4195	1/26/2052 0:00	10252	166.4654
9/11/2051 0:00	10115	166.3282	10/27/2051 0:00	10161	166.3745	12/12/2051 0:00	10207	166.4205	1/27/2052 0:00	10253	166.4664
9/12/2051 0:00	10116	166.3292	10/28/2051 0:00	10162	166.3755	12/13/2051 0:00	10208	166.4215	1/28/2052 0:00	10254	166.4674
9/13/2051 0:00	10117	166.3302	10/29/2051 0:00	10163	166.3765	12/14/2051 0:00	10209	166.4225	1/29/2052 0:00	10255	166.4684
9/14/2051 0:00	10118	166.3312	10/30/2051 0:00	10164	166.3775	12/15/2051 0:00	10210	166.4235	1/30/2052 0:00	10256	166.4694
9/15/2051 0:00	10119	166.3322	10/31/2051 0:00	10165	166.3785	12/16/2051 0:00	10211	166.4245	1/31/2052 0:00	10257	166.4704
9/16/2051 0:00	10120	166.3332	11/1/2051 0:00	10166	166.3795	12/17/2051 0:00	10212	166.4255	2/1/2052 0:00	10258	166.4714
9/17/2051 0:00	10121	166.3342	11/2/2051 0:00	10167	166.3805	12/18/2051 0:00	10213	166.4265	2/2/2052 0:00	10259	166.4724
9/18/2051 0:00	10122	166.3352	11/3/2051 0:00	10168	166.3815	12/19/2051 0:00	10214	166.4275	2/3/2052 0:00	10260	166.4734
9/19/2051 0:00	10123	166.3362	11/4/2051 0:00	10169	166.3825	12/20/2051 0:00	10215	166.4285	2/4/2052 0:00	10261	166.4744
9/20/2051 0:00	10124	166.3372	11/5/2051 0:00	10170	166.3835	12/21/2051 0:00	10216	166.4295	2/5/2052 0:00	10262	166.4754
9/21/2051 0:00	10125	166.3382	11/6/2051 0:00	10171	166.3845	12/22/2051 0:00	10217	166.4305	2/6/2052 0:00	10263	166.4763
9/22/2051 0:00	10126	166.3393	11/7/2051 0:00	10172	166.3855	12/23/2051 0:00	10218	166.4315	2/7/2052 0:00	10264	166.4773
9/23/2051 0:00	10127	166.3403	11/8/2051 0:00	10173	166.3865	12/24/2051 0:00	10219	166.4325	2/8/2052 0:00	10265	166.4783
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9/25/2051 0:00	10129	166.3423	11/10/2051 0:00	10175	166.3885	12/26/2051 0:00	10221	166.4345	2/10/2052 0:00	10267	166.4803
9/26/2051 0:00	10130	166.3433	11/11/2051 0:00	10176	166.3895	12/27/2051 0:00	10222	166.4355	2/11/2052 0:00	10268	166.4813
9/27/2051 0:00	10131	166.3443	11/12/2051 0:00	10177	166.3905	12/28/2051 0:00	10223	166.4365	2/12/2052 0:00	10269	166.4823
9/28/2051 0:00	10132	166.3453	11/13/2051 0:00	10178	166.3915	12/29/2051 0:00	10224	166.4375	2/13/2052 0:00	10270	166.4833
9/29/2051 0:00	10133	166.3463	11/14/2051 0:00	10179	166.3925	12/30/2051 0:00	10225	166.4385	2/14/2052 0:00	10271	166.4843
9/30/2051 0:00	10134	166.3473	11/15/2051 0:00	10180	166.3935	12/31/2051 0:00	10226	166.4395	2/15/2052 0:00	10272	166.4853
10/1/2051 0:00	10135	166.3483	11/16/2051 0:00	10181	166.3945	1/1/2052 0:00	10227	166.4405	2/16/2052 0:00	10273	166.4863
10/2/2051 0:00	10136	166.3493	11/17/2051 0:00	10182	166.3955	1/2/2052 0:00	10228	166.4415	2/17/2052 0:00	10274	166.4873
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10/4/2051 0:00	10138	166.3513	11/19/2051 0:00	10184	166.3975	1/4/2052 0:00	10230	166.4435	2/19/2052 0:00	10276	166.4893
10/5/2051 0:00	10139	166.3523	11/20/2051 0:00	10185	166.3985	1/5/2052 0:00	10231	166.4445	2/20/2052 0:00	10277	166.4903
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10/8/2051 0:00	10142	166.3554	11/23/2051 0:00	10188	166.4015	1/8/2052 0:00	10234	166.4475	2/23/2052 0:00	10280	166.4932
10/9/2051 0:00	10143	166.3564	11/24/2051 0:00	10189	166.4025	1/9/2052 0:00	10235	166.4485	2/24/2052 0:00	10281	166.4942
10/10/2051 0:00	10144	166.3574	11/25/2051 0:00	10190	166.4035	1/10/2052 0:00	10236	166.4495	2/25/2052 0:00	10282	166.4952
10/11/2051 0:00	10145	166.3584	11/26/2051 0:00	10191	166.4045	1/11/2052 0:00	10237	166.4505	2/26/2052 0:00	10283	166.4962
10/12/2051 0:00	10146	166.3594	11/27/2051 0:00	10192	166.4055	1/12/2052 0:00	10238	166.4515	2/27/2052 0:00	10284	166.4972
10/13/2051 0:00	10147	166.3604	11/28/2051 0:00	10193	166.4065	1/13/2052 0:00	10239	166.4525	2/28/2052 0:00	10285	166.4982
10/14/2051 0:00	10148	166.3614	11/29/2051 0:00	10194	166.4075	1/14/2052 0:00	10240	166.4535	2/29/2052 0:00	10286	166.4992
10/15/2051 0:00	10149	166.3624	11/30/2051 0:00	10195	166.4085	1/15/2052 0:00	10241	166.4545	3/1/2052 0:00	10287	166.5002
10/16/2051 0:00	10150	166.3634	12/1/2051 0:00	10196	166.4095	1/16/2052 0:00	10242	166.4555	3/2/2052 0:00	10288	166.5012
10/17/2051 0:00	10151	166.3644	12/2/2051 0:00	10197	166.4105	1/17/2052 0:00	10243	166.4564	3/3/2052 0:00	10289	166.5022
10/18/2051 0:00	10152	166.3654	12/3/2051 0:00	10198	166.4115	1/18/2052 0:00	10244	166.4574	3/4/2052 0:00	10290	166.5031
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3/6/2052 0:00	10292	166.5051	4/21/2052 0:00	10338	166.5506	6/6/2052 0:00	10384	166.5959	7/22/2052 0:00	10430	166.641
3/7/2052 0:00	10293	166.5061	4/22/2052 0:00	10339	166.5516	6/7/2052 0:00	10385	166.5969	7/23/2052 0:00	10431	166.642
3/8/2052 0:00	10294	166.5071	4/23/2052 0:00	10340	166.5526	6/8/2052 0:00	10386	166.5979	7/24/2052 0:00	10432	166.643
3/9/2052 0:00	10295	166.5081	4/24/2052 0:00	10341	166.5536	6/9/2052 0:00	10387	166.5989	7/25/2052 0:00	10433	166.6439
3/10/2052 0:00	10296	166.5091	4/25/2052 0:00	10342	166.5546	6/10/2052 0:00	10388	166.5998	7/26/2052 0:00	10434	166.6449
3/11/2052 0:00	10297	166.5101	4/26/2052 0:00	10343	166.5556	6/11/2052 0:00	10389	166.6008	7/27/2052 0:00	10435	166.6459
3/12/2052 0:00	10298	166.5111	4/27/2052 0:00	10344	166.5565	6/12/2052 0:00	10390	166.6018	7/28/2052 0:00	10436	166.6469
3/13/2052 0:00	10299	166.5121	4/28/2052 0:00	10345	166.5575	6/13/2052 0:00	10391	166.6028	7/29/2052 0:00	10437	166.6479
3/14/2052 0:00	10300	166.5131	4/29/2052 0:00	10346	166.5585	6/14/2052 0:00	10392	166.6038	7/30/2052 0:00	10438	166.6488
3/15/2052 0:00	10301	166.514	4/30/2052 0:00	10347	166.5595	6/15/2052 0:00	10393	166.6048	7/31/2052 0:00	10439	166.6498
3/16/2052 0:00	10302	166.515	5/1/2052 0:00	10348	166.5605	6/16/2052 0:00	10394	166.6057	8/1/2052 0:00	10440	166.6508
3/17/2052 0:00	10303	166.516	5/2/2052 0:00	10349	166.5615	6/17/2052 0:00	10395	166.6067	8/2/2052 0:00	10441	166.6518
3/18/2052 0:00	10304	166.517	5/3/2052 0:00	10350	166.5625	6/18/2052 0:00	10396	166.6077	8/3/2052 0:00	10442	166.6527
3/19/2052 0:00	10305	166.518	5/4/2052 0:00	10351	166.5634	6/19/2052 0:00	10397	166.6087	8/4/2052 0:00	10443	166.6537
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3/21/2052 0:00	10307	166.52	5/6/2052 0:00	10353	166.5654	6/21/2052 0:00	10399	166.6106	8/6/2052 0:00	10445	166.6557
3/22/2052 0:00	10308	166.521	5/7/2052 0:00	10354	166.5664	6/22/2052 0:00	10400	166.6116	8/7/2052 0:00	10446	166.6566
3/23/2052 0:00	10309	166.522	5/8/2052 0:00	10355	166.5674	6/23/2052 0:00	10401	166.6126	8/8/2052 0:00	10447	166.6576
3/24/2052 0:00	10310	166.523	5/9/2052 0:00	10356	166.5684	6/24/2052 0:00	10402	166.6136	8/9/2052 0:00	10448	166.6586
3/25/2052 0:00	10311	166.5239	5/10/2052 0:00	10357	166.5694	6/25/2052 0:00	10403	166.6146	8/10/2052 0:00	10449	166.6596
3/26/2052 0:00	10312	166.5249	5/11/2052 0:00	10358	166.5703	6/26/2052 0:00	10404	166.6155	8/11/2052 0:00	10450	166.6606
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3/28/2052 0:00	10314	166.5269	5/13/2052 0:00	10360	166.5723	6/28/2052 0:00	10406	166.6175	8/13/2052 0:00	10452	166.6625
3/29/2052 0:00	10315	166.5279	5/14/2052 0:00	10361	166.5733	6/29/2052 0:00	10407	166.6185	8/14/2052 0:00	10453	166.6635
3/30/2052 0:00	10316	166.5289	5/15/2052 0:00	10362	166.5743	6/30/2052 0:00	10408	166.6195	8/15/2052 0:00	10454	166.6645
3/31/2052 0:00	10317	166.5299	5/16/2052 0:00	10363	166.5753	7/1/2052 0:00	10409	166.6204	8/16/2052 0:00	10455	166.6654
4/1/2052 0:00	10318	166.5309	5/17/2052 0:00	10364	166.5762	7/2/2052 0:00	10410	166.6214	8/17/2052 0:00	10456	166.6664
4/2/2052 0:00	10319	166.5319	5/18/2052 0:00	10365	166.5772	7/3/2052 0:00	10411	166.6224	8/18/2052 0:00	10457	166.6674
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4/6/2052 0:00	10323	166.5358	5/22/2052 0:00	10369	166.5812	7/7/2052 0:00	10415	166.6263	8/22/2052 0:00	10461	166.6713
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4/16/2052 0:00	10333	166.5457	6/1/2052 0:00	10379	166.591	7/17/2052 0:00	10425	166.6361	9/1/2052 0:00	10471	166.681
4/17/2052 0:00	10334	166.5467	6/2/2052 0:00	10380	166.592	7/18/2052 0:00	10426	166.6371	9/2/2052 0:00	10472	166.682
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9/8/2052 0:00	10478	166.6878	10/24/2052 0:00	10524	166.7325	12/9/2052 0:00	10570	166.777	1/24/2053 0:00	10616	166.8213
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9/17/2052 0:00	10487	166.6966	11/2/2052 0:00	10533	166.7413	12/18/2052 0:00	10579	166.7857	2/2/2053 0:00	10625	166.83
9/18/2052 0:00	10488	166.6976	11/3/2052 0:00	10534	166.7422	12/19/2052 0:00	10580	166.7867	2/3/2053 0:00	10626	166.8309
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9/28/2052 0:00	10498	166.7073	11/13/2052 0:00	10544	166.7519	12/29/2052 0:00	10590	166.7963	2/13/2053 0:00	10636	166.8405
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10/9/2052 0:00	10509	166.718	11/24/2052 0:00	10555	166.7625	1/9/2053 0:00	10601	166.8069	2/24/2053 0:00	10647	166.8511
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3/14/2053 0:00	10665	166.8683	4/29/2053 0:00	10711	166.9122	6/14/2053 0:00	10757	166.9559	7/30/2053 0:00	10803	166.9995
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3/26/2053 0:00	10677	166.8798	5/11/2053 0:00	10723	166.9236	6/26/2053 0:00	10769	166.9673	8/11/2053 0:00	10815	167.0108
3/27/2053 0:00	10678	166.8807	5/12/2053 0:00	10724	166.9246	6/27/2053 0:00	10770	166.9683	8/12/2053 0:00	10816	167.0117
3/28/2053 0:00	10679	166.8817	5/13/2053 0:00	10725	166.9255	6/28/2053 0:00	10771	166.9692	8/13/2053 0:00	10817	167.0127
3/29/2053 0:00	10680	166.8826	5/14/2053 0:00	10726	166.9265	6/29/2053 0:00	10772	166.9701	8/14/2053 0:00	10818	167.0136
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3/31/2053 0:00	10682	166.8846	5/16/2053 0:00	10728	166.9284	7/1/2053 0:00	10774	166.972	8/16/2053 0:00	10820	167.0155
4/1/2053 0:00	10683	166.8855	5/17/2053 0:00	10729	166.9293	7/2/2053 0:00	10775	166.973	8/17/2053 0:00	10821	167.0164
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4/7/2053 0:00	10689	166.8912	5/23/2053 0:00	10735	166.935	7/8/2053 0:00	10781	166.9787	8/23/2053 0:00	10827	167.0221
4/8/2053 0:00	10690	166.8922	5/24/2053 0:00	10736	166.936	7/9/2053 0:00	10782	166.9796	8/24/2053 0:00	10828	167.023
4/9/2053 0:00	10691	166.8931	5/25/2053 0:00	10737	166.9369	7/10/2053 0:00	10783	166.9806	8/25/2053 0:00	10829	167.024
4/10/2053 0:00	10692	166.8941	5/26/2053 0:00	10738	166.9379	7/11/2053 0:00	10784	166.9815	8/26/2053 0:00	10830	167.0249
4/11/2053 0:00	10693	166.8951	5/27/2053 0:00	10739	166.9388	7/12/2053 0:00	10785	166.9825	8/27/2053 0:00	10831	167.0259
4/12/2053 0:00	10694	166.896	5/28/2053 0:00	10740	166.9398	7/13/2053 0:00	10786	166.9834	8/28/2053 0:00	10832	167.0268
4/13/2053 0:00	10695	166.897	5/29/2053 0:00	10741	166.9407	7/14/2053 0:00	10787	166.9843	8/29/2053 0:00	10833	167.0278
4/14/2053 0:00	10696	166.8979	5/30/2053 0:00	10742	166.9417	7/15/2053 0:00	10788	166.9853	8/30/2053 0:00	10834	167.0287
4/15/2053 0:00	10697	166.8989	5/31/2053 0:00	10743	166.9426	7/16/2053 0:00	10789	166.9862	8/31/2053 0:00	10835	167.0296
4/16/2053 0:00	10698	166.8998	6/1/2053 0:00	10744	166.9436	7/17/2053 0:00	10790	166.9872	9/1/2053 0:00	10836	167.0306
4/17/2053 0:00	10699	166.9008	6/2/2053 0:00	10745	166.9445	7/18/2053 0:00	10791	166.9881	9/2/2053 0:00	10837	167.0315
4/18/2053 0:00	10700	166.9017	6/3/2053 0:00	10746	166.9455	7/19/2053 0:00	10792	166.9891	9/3/2053 0:00	10838	167.0325
4/19/2053 0:00	10701	166.9027	6/4/2053 0:00	10747	166.9464	7/20/2053 0:00	10793	166.99	9/4/2053 0:00	10839	167.0334
4/20/2053 0:00	10702	166.9036	6/5/2053 0:00	10748	166.9474	7/21/2053 0:00	10794	166.991	9/5/2053 0:00	10840	167.0343
4/21/2053 0:00	10703	166.9046	6/6/2053 0:00	10749	166.9483	7/22/2053 0:00	10795	166.9919	9/6/2053 0:00	10841	167.0353
4/22/2053 0:00	10704	166.9055	6/7/2053 0:00	10750	166.9493	7/23/2053 0:00	10796	166.9929	9/7/2053 0:00	10842	167.0362
4/23/2053 0:00	10705	166.9065	6/8/2053 0:00	10751	166.9502	7/24/2053 0:00	10797	166.9938	9/8/2053 0:00	10843	167.0372

9/9/2053 0:00	10844	167.0381	10/25/2053 0:00	10890	167.0813	12/10/2053 0:00	10936	167.1243	1/25/2054 0:00	10982	61.0261
9/10/2053 0:00	10845	167.039	10/26/2053 0:00	10891	167.0822	12/11/2053 0:00	10937	167.1252	1/26/2054 0:00	10983	60.6659
9/11/2053 0:00	10846	167.04	10/27/2053 0:00	10892	167.0832	12/12/2053 0:00	10938	167.1262	1/27/2054 0:00	10984	60.3181
9/12/2053 0:00	10847	167.0409	10/28/2053 0:00	10893	167.0841	12/13/2053 0:00	10939	167.1271	1/28/2054 0:00	10985	59.9818
9/13/2053 0:00	10848	167.0419	10/29/2053 0:00	10894	167.085	12/14/2053 0:00	10940	167.128	1/29/2054 0:00	10986	59.6563
9/14/2053 0:00	10849	167.0428	10/30/2053 0:00	10895	167.086	12/15/2053 0:00	10941	167.129	1/30/2054 0:00	10987	59.341
9/15/2053 0:00	10850	167.0438	10/31/2053 0:00	10896	167.0869	12/16/2053 0:00	10942	167.1299	1/31/2054 0:00	10988	59.0352
9/16/2053 0:00	10851	167.0447	11/1/2053 0:00	10897	167.0878	12/17/2053 0:00	10943	167.1308	2/1/2054 0:00	10989	58.7383
9/17/2053 0:00	10852	167.0456	11/2/2053 0:00	10898	167.0888	12/18/2053 0:00	10944	167.1318	2/2/2054 0:00	10990	58.4499
9/18/2053 0:00	10853	167.0466	11/3/2053 0:00	10899	167.0897	12/19/2053 0:00	10945	167.1327	2/3/2054 0:00	10991	58.1695
9/19/2053 0:00	10854	167.0475	11/4/2053 0:00	10900	167.0907	12/20/2053 0:00	10946	167.1336	2/4/2054 0:00	10992	57.8967
9/20/2053 0:00	10855	167.0485	11/5/2053 0:00	10901	167.0916	12/21/2053 0:00	10947	167.1345	2/5/2054 0:00	10993	57.631
9/21/2053 0:00	10856	167.0494	11/6/2053 0:00	10902	167.0925	12/22/2053 0:00	10948	167.1355	2/6/2054 0:00	10994	57.3721
9/22/2053 0:00	10857	167.0503	11/7/2053 0:00	10903	167.0935	12/23/2053 0:00	10949	167.1364	2/7/2054 0:00	10995	57.1196
9/23/2053 0:00	10858	167.0513	11/8/2053 0:00	10904	167.0944	12/24/2053 0:00	10950	167.1373	2/8/2054 0:00	10996	56.8733
9/24/2053 0:00	10859	167.0522	11/9/2053 0:00	10905	167.0953	12/25/2053 0:00	10951	167.1383	2/9/2054 0:00	10997	56.6329
9/25/2053 0:00	10860	167.0531	11/10/2053 0:00	10906	167.0963	12/26/2053 0:00	10952	167.1392	2/10/2054 0:00	10998	56.398
9/26/2053 0:00	10861	167.0541	11/11/2053 0:00	10907	167.0972	12/27/2053 0:00	10953	167.1401	2/11/2054 0:00	10999	56.1684
9/27/2053 0:00	10862	167.055	11/12/2053 0:00	10908	167.0981	12/28/2053 0:00	10954	167.1411	2/12/2054 0:00	11000	55.944
9/28/2053 0:00	10863	167.056	11/13/2053 0:00	10909	167.0991	12/29/2053 0:00	10955	167.142	2/13/2054 0:00	11001	55.7244
9/29/2053 0:00	10864	167.0569	11/14/2053 0:00	10910	167.1	12/30/2053 0:00	10956	167.1429	2/14/2054 0:00	11002	55.5095
9/30/2053 0:00	10865	167.0578	11/15/2053 0:00	10911	167.1009	12/31/2053 0:00	10957	167.1439	2/15/2054 0:00	11003	55.2991
10/1/2053 0:00	10866	167.0588	11/16/2053 0:00	10912	167.1019	1/1/2054 0:00	10958	167.1448	2/16/2054 0:00	11004	55.0929
10/2/2053 0:00	10867	167.0597	11/17/2053 0:00	10913	167.1028	1/2/2054 0:00	10959	81.6467	2/17/2054 0:00	11005	54.8909
10/3/2053 0:00	10868	167.0607	11/18/2053 0:00	10914	167.1037	1/3/2054 0:00	10960	78.0862	2/18/2054 0:00	11006	54.6928
10/4/2053 0:00	10869	167.0616	11/19/2053 0:00	10915	167.1047	1/4/2054 0:00	10961	75.9206	2/19/2054 0:00	11007	54.4986
10/5/2053 0:00	10870	167.0625	11/20/2053 0:00	10916	167.1056	1/5/2054 0:00	10962	74.2878	2/20/2054 0:00	11008	54.308
10/6/2053 0:00	10871	167.0635	11/21/2053 0:00	10917	167.1066	1/6/2054 0:00	10963	72.9408	2/21/2054 0:00	11009	54.1209
10/7/2053 0:00	10872	167.0644	11/22/2053 0:00	10918	167.1075	1/7/2054 0:00	10964	71.7783	2/22/2054 0:00	11010	53.9372
10/8/2053 0:00	10873	167.0654	11/23/2053 0:00	10919	167.1084	1/8/2054 0:00	10965	70.7486	2/23/2054 0:00	11011	53.7568
10/9/2053 0:00	10874	167.0663	11/24/2053 0:00	10920	167.1094	1/9/2054 0:00	10966	69.8209	2/24/2054 0:00	11012	53.5796
10/10/2053 0:00	10875	167.0672	11/25/2053 0:00	10921	167.1103	1/10/2054 0:00	10967	68.975	2/25/2054 0:00	11013	53.4054
10/11/2053 0:00	10876	167.0682	11/26/2053 0:00	10922	167.1112	1/11/2054 0:00	10968	68.1966	2/26/2054 0:00	11014	53.2342
10/12/2053 0:00	10877	167.0691	11/27/2053 0:00	10923	167.1122	1/12/2054 0:00	10969	67.4753	2/27/2054 0:00	11015	53.0659
10/13/2053 0:00	10878	167.07	11/28/2053 0:00	10924	167.1131	1/13/2054 0:00	10970	66.8028	2/28/2054 0:00	11016	52.9003
10/14/2053 0:00	10879	167.071	11/29/2053 0:00	10925	167.114	1/14/2054 0:00	10971	66.1728	3/1/2054 0:00	11017	52.7374
10/15/2053 0:00	10880	167.0719	11/30/2053 0:00	10926	167.115	1/15/2054 0:00	10972	65.5801	3/2/2054 0:00	11018	52.577
10/16/2053 0:00	10881	167.0729	12/1/2053 0:00	10927	167.1159	1/16/2054 0:00	10973	65.0204	3/3/2054 0:00	11019	52.4192
10/17/2053 0:00	10882	167.0738	12/2/2053 0:00	10928	167.1168	1/17/2054 0:00	10974	64.4902	3/4/2054 0:00	11020	52.2638
10/18/2053 0:00	10883	167.0747	12/3/2053 0:00	10929	167.1178	1/18/2054 0:00	10975	63.9865	3/5/2054 0:00	11021	52.1108
10/19/2053 0:00	10884	167.0757	12/4/2053 0:00	10930	167.1187	1/19/2054 0:00	10976	63.5067	3/6/2054 0:00	11022	51.9601
10/20/2053 0:00	10885	167.0766	12/5/2053 0:00	10931	167.1196	1/20/2054 0:00	10977	63.0487	3/7/2054 0:00	11023	51.8115
10/21/2053 0:00	10886	167.0775	12/6/2053 0:00	10932	167.1206	1/21/2054 0:00	10978	62.6106	3/8/2054 0:00	11024	51.6652
10/22/2053 0:00	10887	167.0785	12/7/2053 0:00	10933	167.1215	1/22/2054 0:00	10979	62.1906	3/9/2054 0:00	11025	51.5209
10/23/2053 0:00	10888	167.0794	12/8/2053 0:00	10934	167.1224	1/23/2054 0:00	10980	61.7874	3/10/2054 0:00	11026	51.3787
10/24/2053 0:00	10889	167.0804	12/9/2053 0:00	10935	167.1234	1/24/2054 0:00	10981	61.3996	3/11/2054 0:00	11027	51.2384

3/12/2054 0:00	11028	51.1001	4/27/2054 0:00	11074	46.198	6/12/2054 0:00	11120	42.9239	7/28/2054 0:00	11166	40.467
3/13/2054 0:00	11029	50.9637	4/28/2054 0:00	11075	46.1141	6/13/2054 0:00	11121	42.8634	7/29/2054 0:00	11167	40.4199
3/14/2054 0:00	11030	50.829	4/29/2054 0:00	11076	46.0309	6/14/2054 0:00	11122	42.8033	7/30/2054 0:00	11168	40.3729
3/15/2054 0:00	11031	50.6962	4/30/2054 0:00	11077	45.9484	6/15/2054 0:00	11123	42.7436	7/31/2054 0:00	11169	40.3262
3/16/2054 0:00	11032	50.5651	5/1/2054 0:00	11078	45.8665	6/16/2054 0:00	11124	42.6842	8/1/2054 0:00	11170	40.2797
3/17/2054 0:00	11033	50.4357	5/2/2054 0:00	11079	45.7853	6/17/2054 0:00	11125	42.6252	8/2/2054 0:00	11171	40.2335
3/18/2054 0:00	11034	50.3079	5/3/2054 0:00	11080	45.7048	6/18/2054 0:00	11126	42.5666	8/3/2054 0:00	11172	40.1874
3/19/2054 0:00	11035	50.1817	5/4/2054 0:00	11081	45.6249	6/19/2054 0:00	11127	42.5083	8/4/2054 0:00	11173	40.1416
3/20/2054 0:00	11036	50.0571	5/5/2054 0:00	11082	45.5456	6/20/2054 0:00	11128	42.4503	8/5/2054 0:00	11174	40.096
3/21/2054 0:00	11037	49.934	5/6/2054 0:00	11083	45.467	6/21/2054 0:00	11129	42.3926	8/6/2054 0:00	11175	40.0506
3/22/2054 0:00	11038	49.8124	5/7/2054 0:00	11084	45.389	6/22/2054 0:00	11130	42.3353	8/7/2054 0:00	11176	40.0054
3/23/2054 0:00	11039	49.6922	5/8/2054 0:00	11085	45.3116	6/23/2054 0:00	11131	42.2784	8/8/2054 0:00	11177	39.9604
3/24/2054 0:00	11040	49.5735	5/9/2054 0:00	11086	45.2348	6/24/2054 0:00	11132	42.2217	8/9/2054 0:00	11178	39.9156
3/25/2054 0:00	11041	49.4561	5/10/2054 0:00	11087	45.1586	6/25/2054 0:00	11133	42.1654	8/10/2054 0:00	11179	39.871
3/26/2054 0:00	11042	49.3402	5/11/2054 0:00	11088	45.0829	6/26/2054 0:00	11134	42.1094	8/11/2054 0:00	11180	39.8266
3/27/2054 0:00	11043	49.2255	5/12/2054 0:00	11089	45.0079	6/27/2054 0:00	11135	42.0537	8/12/2054 0:00	11181	39.7824
3/28/2054 0:00	11044	49.1121	5/13/2054 0:00	11090	44.9333	6/28/2054 0:00	11136	41.9983	8/13/2054 0:00	11182	39.7384
3/29/2054 0:00	11045	49	5/14/2054 0:00	11091	44.8594	6/29/2054 0:00	11137	41.9433	8/14/2054 0:00	11183	39.6946
3/30/2054 0:00	11046	48.8892	5/15/2054 0:00	11092	44.786	6/30/2054 0:00	11138	41.8885	8/15/2054 0:00	11184	39.651
3/31/2054 0:00	11047	48.7795	5/16/2054 0:00	11093	44.7131	7/1/2054 0:00	11139	41.834	8/16/2054 0:00	11185	39.6076
4/1/2054 0:00	11048	48.671	5/17/2054 0:00	11094	44.6408	7/2/2054 0:00	11140	41.7799	8/17/2054 0:00	11186	39.5644
4/2/2054 0:00	11049	48.5637	5/18/2054 0:00	11095	44.5689	7/3/2054 0:00	11141	41.726	8/18/2054 0:00	11187	39.5214
4/3/2054 0:00	11050	48.4576	5/19/2054 0:00	11096	44.4976	7/4/2054 0:00	11142	41.6725	8/19/2054 0:00	11188	39.4786
4/4/2054 0:00	11051	48.3525	5/20/2054 0:00	11097	44.4268	7/5/2054 0:00	11143	41.6192	8/20/2054 0:00	11189	39.4359
4/5/2054 0:00	11052	48.2485	5/21/2054 0:00	11098	44.3565	7/6/2054 0:00	11144	41.5662	8/21/2054 0:00	11190	39.3935
4/6/2054 0:00	11053	48.1456	5/22/2054 0:00	11099	44.2867	7/7/2054 0:00	11145	41.5135	8/22/2054 0:00	11191	39.3512
4/7/2054 0:00	11054	48.0438	5/23/2054 0:00	11100	44.2174	7/8/2054 0:00	11146	41.461	8/23/2054 0:00	11192	39.3091
4/8/2054 0:00	11055	47.9429	5/24/2054 0:00	11101	44.1486	7/9/2054 0:00	11147	41.4089	8/24/2054 0:00	11193	39.2672
4/9/2054 0:00	11056	47.8431	5/25/2054 0:00	11102	44.0802	7/10/2054 0:00	11148	41.357	8/25/2054 0:00	11194	39.2254
4/10/2054 0:00	11057	47.7443	5/26/2054 0:00	11103	44.0123	7/11/2054 0:00	11149	41.3054	8/26/2054 0:00	11195	39.1839
4/11/2054 0:00	11058	47.6464	5/27/2054 0:00	11104	43.9449	7/12/2054 0:00	11150	41.254	8/27/2054 0:00	11196	39.1425
4/12/2054 0:00	11059	47.5494	5/28/2054 0:00	11105	43.8779	7/13/2054 0:00	11151	41.203	8/28/2054 0:00	11197	39.1013
4/13/2054 0:00	11060	47.4534	5/29/2054 0:00	11106	43.8113	7/14/2054 0:00	11152	41.1522	8/29/2054 0:00	11198	39.0603
4/14/2054 0:00	11061	47.3584	5/30/2054 0:00	11107	43.7452	7/15/2054 0:00	11153	41.1016	8/30/2054 0:00	11199	39.0194
4/15/2054 0:00	11062	47.2642	5/31/2054 0:00	11108	43.6796	7/16/2054 0:00	11154	41.0513	8/31/2054 0:00	11200	38.9787
4/16/2054 0:00	11063	47.1708	6/1/2054 0:00	11109	43.6144	7/17/2054 0:00	11155	41.0013	9/1/2054 0:00	11201	38.9382
4/17/2054 0:00	11064	47.0784	6/2/2054 0:00	11110	43.5496	7/18/2054 0:00	11156	40.9515	9/2/2054 0:00	11202	38.8978
4/18/2054 0:00	11065	46.9868	6/3/2054 0:00	11111	43.4852	7/19/2054 0:00	11157	40.902	9/3/2054 0:00	11203	38.8576
4/19/2054 0:00	11066	46.896	6/4/2054 0:00	11112	43.4212	7/20/2054 0:00	11158	40.8527	9/4/2054 0:00	11204	38.8176
4/20/2054 0:00	11067	46.806	6/5/2054 0:00	11113	43.3577	7/21/2054 0:00	11159	40.8036	9/5/2054 0:00	11205	38.7777
4/21/2054 0:00	11068	46.7169	6/6/2054 0:00	11114	43.2945	7/22/2054 0:00	11160	40.7548	9/6/2054 0:00	11206	38.738
4/22/2054 0:00	11069	46.6285	6/7/2054 0:00	11115	43.2318	7/23/2054 0:00	11161	40.7063	9/7/2054 0:00	11207	38.6985
4/23/2054 0:00	11070	46.5409	6/8/2054 0:00	11116	43.1694	7/24/2054 0:00	11162	40.658	9/8/2054 0:00	11208	38.6591
4/24/2054 0:00	11071	46.4541	6/9/2054 0:00	11117	43.1075	7/25/2054 0:00	11163	40.6099	9/9/2054 0:00	11209	38.6199
4/25/2054 0:00	11072	46.368	6/10/2054 0:00	11118	43.0459	7/26/2054 0:00	11164	40.562	9/10/2054 0:00	11210	38.5808
4/26/2054 0:00	11073	46.2826	6/11/2054 0:00	11119	42.9847	7/27/2054 0:00	11165	40.5144	9/11/2054 0:00	11211	38.5419

9/12/2054 0:00	11212	38.5032	10/28/2054 0:00	11258	36.8694	12/13/2054 0:00	11304	35.4721	1/28/2055 0:00	11350	34.2527
9/13/2054 0:00	11213	38.4646	10/29/2054 0:00	11259	36.8367	12/14/2054 0:00	11305	35.4439	1/29/2055 0:00	11351	34.2278
9/14/2054 0:00	11214	38.4261	10/30/2054 0:00	11260	36.8042	12/15/2054 0:00	11306	35.4157	1/30/2055 0:00	11352	34.203
9/15/2054 0:00	11215	38.3878	10/31/2054 0:00	11261	36.7718	12/16/2054 0:00	11307	35.3876	1/31/2055 0:00	11353	34.1783
9/16/2054 0:00	11216	38.3497	11/1/2054 0:00	11262	36.7395	12/17/2054 0:00	11308	35.3597	2/1/2055 0:00	11354	34.1536
9/17/2054 0:00	11217	38.3117	11/2/2054 0:00	11263	36.7073	12/18/2054 0:00	11309	35.3318	2/2/2055 0:00	11355	34.1291
9/18/2054 0:00	11218	38.2738	11/3/2054 0:00	11264	36.6752	12/19/2054 0:00	11310	35.3039	2/3/2055 0:00	11356	34.1045
9/19/2054 0:00	11219	38.2361	11/4/2054 0:00	11265	36.6432	12/20/2054 0:00	11311	35.2762	2/4/2055 0:00	11357	34.0801
9/20/2054 0:00	11220	38.1986	11/5/2054 0:00	11266	36.6113	12/21/2054 0:00	11312	35.2485	2/5/2055 0:00	11358	34.0556
9/21/2054 0:00	11221	38.1612	11/6/2054 0:00	11267	36.5796	12/22/2054 0:00	11313	35.221	2/6/2055 0:00	11359	34.0313
9/22/2054 0:00	11222	38.1239	11/7/2054 0:00	11268	36.5479	12/23/2054 0:00	11314	35.1935	2/7/2055 0:00	11360	34.007
9/23/2054 0:00	11223	38.0868	11/8/2054 0:00	11269	36.5163	12/24/2054 0:00	11315	35.166	2/8/2055 0:00	11361	33.9828
9/24/2054 0:00	11224	38.0498	11/9/2054 0:00	11270	36.4849	12/25/2054 0:00	11316	35.1387	2/9/2055 0:00	11362	33.9586
9/25/2054 0:00	11225	38.0129	11/10/2054 0:00	11271	36.4535	12/26/2054 0:00	11317	35.1114	2/10/2055 0:00	11363	33.9345
9/26/2054 0:00	11226	37.9762	11/11/2054 0:00	11272	36.4223	12/27/2054 0:00	11318	35.0842	2/11/2055 0:00	11364	33.9105
9/27/2054 0:00	11227	37.9396	11/12/2054 0:00	11273	36.3911	12/28/2054 0:00	11319	35.0571	2/12/2055 0:00	11365	33.8865
9/28/2054 0:00	11228	37.9032	11/13/2054 0:00	11274	36.36	12/29/2054 0:00	11320	35.0301	2/13/2055 0:00	11366	33.8626
9/29/2054 0:00	11229	37.8669	11/14/2054 0:00	11275	36.3291	12/30/2054 0:00	11321	35.0031	2/14/2055 0:00	11367	33.8388
9/30/2054 0:00	11230	37.8308	11/15/2054 0:00	11276	36.2982	12/31/2054 0:00	11322	34.9762	2/15/2055 0:00	11368	33.815
10/1/2054 0:00	11231	37.7947	11/16/2054 0:00	11277	36.2675	1/1/2055 0:00	11323	34.9494	2/16/2055 0:00	11369	33.7912
10/2/2054 0:00	11232	37.7588	11/17/2054 0:00	11278	36.2368	1/2/2055 0:00	11324	34.9227	2/17/2055 0:00	11370	33.7676
10/3/2054 0:00	11233	37.7231	11/18/2054 0:00	11279	36.2062	1/3/2055 0:00	11325	34.896	2/18/2055 0:00	11371	33.7439
10/4/2054 0:00	11234	37.6874	11/19/2054 0:00	11280	36.1758	1/4/2055 0:00	11326	34.8695	2/19/2055 0:00	11372	33.7204
10/5/2054 0:00	11235	37.6519	11/20/2054 0:00	11281	36.1454	1/5/2055 0:00	11327	34.8429	2/20/2055 0:00	11373	33.6969
10/6/2054 0:00	11236	37.6166	11/21/2054 0:00	11282	36.1151	1/6/2055 0:00	11328	34.8165	2/21/2055 0:00	11374	33.6734
10/7/2054 0:00	11237	37.5813	11/22/2054 0:00	11283	36.085	1/7/2055 0:00	11329	34.7901	2/22/2055 0:00	11375	33.6501
10/8/2054 0:00	11238	37.5462	11/23/2054 0:00	11284	36.0549	1/8/2055 0:00	11330	34.7638	2/23/2055 0:00	11376	33.6267
10/9/2054 0:00	11239	37.5112	11/24/2054 0:00	11285	36.0249	1/9/2055 0:00	11331	34.7376	2/24/2055 0:00	11377	33.6035
10/10/2054 0:00	11240	37.4764	11/25/2054 0:00	11286	35.995	1/10/2055 0:00	11332	34.7115	2/25/2055 0:00	11378	33.5802
10/11/2054 0:00	11241	37.4416	11/26/2054 0:00	11287	35.9652	1/11/2055 0:00	11333	34.6854	2/26/2055 0:00	11379	33.5571
10/12/2054 0:00	11242	37.407	11/27/2054 0:00	11288	35.9354	1/12/2055 0:00	11334	34.6594	2/27/2055 0:00	11380	33.534
10/13/2054 0:00	11243	37.3725	11/28/2054 0:00	11289	35.9058	1/13/2055 0:00	11335	34.6335	2/28/2055 0:00	11381	33.511
10/14/2054 0:00	11244	37.3381	11/29/2054 0:00	11290	35.8763	1/14/2055 0:00	11336	34.6076	3/1/2055 0:00	11382	33.488
10/15/2054 0:00	11245	37.3039	11/30/2054 0:00	11291	35.8468	1/15/2055 0:00	11337	34.5818	3/2/2055 0:00	11383	33.465
10/16/2054 0:00	11246	37.2698	12/1/2054 0:00	11292	35.8175	1/16/2055 0:00	11338	34.5561	3/3/2055 0:00	11384	33.4422
10/17/2054 0:00	11247	37.2358	12/2/2054 0:00	11293	35.7882	1/17/2055 0:00	11339	34.5304	3/4/2055 0:00	11385	33.4193
10/18/2054 0:00	11248	37.2019	12/3/2054 0:00	11294	35.7591	1/18/2055 0:00	11340	34.5048	3/5/2055 0:00	11386	33.3966
10/19/2054 0:00	11249	37.1681	12/4/2054 0:00	11295	35.73	1/19/2055 0:00	11341	34.4793	3/6/2055 0:00	11387	33.3739
10/20/2054 0:00	11250	37.1345	12/5/2054 0:00	11296	35.701	1/20/2055 0:00	11342	34.4539	3/7/2055 0:00	11388	33.3512
10/21/2054 0:00	11251	37.1009	12/6/2054 0:00	11297	35.6721	1/21/2055 0:00	11343	34.4285	3/8/2055 0:00	11389	33.3286
10/22/2054 0:00	11252	37.0675	12/7/2054 0:00	11298	35.6432	1/22/2055 0:00	11344	34.4032	3/9/2055 0:00	11390	33.3061
10/23/2054 0:00	11253	37.0342	12/8/2054 0:00	11299	35.6145	1/23/2055 0:00	11345	34.3779	3/10/2055 0:00	11391	33.2836
10/24/2054 0:00	11254	37.001	12/9/2054 0:00	11300	35.5858	1/24/2055 0:00	11346	34.3527	3/11/2055 0:00	11392	33.2611
10/25/2054 0:00	11255	36.9679	12/10/2054 0:00	11301	35.5573	1/25/2055 0:00	11347	34.3276	3/12/2055 0:00	11393	33.2387
10/26/2054 0:00	11256	36.935	12/11/2054 0:00	11302	35.5288	1/26/2055 0:00	11348	34.3026	3/13/2055 0:00	11394	33.2164
10/27/2054 0:00	11257	36.9021	12/12/2054 0:00	11303	35.5004	1/27/2055 0:00	11349	34.2776	3/14/2055 0:00	11395	33.1941

3/15/2055 0:00	11396	33.1719	4/30/2055 0:00	11442	32.2022	6/15/2055 0:00	11488	31.3234	7/31/2055 0:00	11534	30.5206
3/16/2055 0:00	11397	33.1497	5/1/2055 0:00	11443	32.1822	6/16/2055 0:00	11489	31.3052	8/1/2055 0:00	11535	30.5039
3/17/2055 0:00	11398	33.1276	5/2/2055 0:00	11444	32.1622	6/17/2055 0:00	11490	31.287	8/2/2055 0:00	11536	30.4872
3/18/2055 0:00	11399	33.1055	5/3/2055 0:00	11445	32.1423	6/18/2055 0:00	11491	31.2689	8/3/2055 0:00	11537	30.4706
3/19/2055 0:00	11400	33.0835	5/4/2055 0:00	11446	32.1224	6/19/2055 0:00	11492	31.2508	8/4/2055 0:00	11538	30.454
3/20/2055 0:00	11401	33.0615	5/5/2055 0:00	11447	32.1025	6/20/2055 0:00	11493	31.2327	8/5/2055 0:00	11539	30.4374
3/21/2055 0:00	11402	33.0396	5/6/2055 0:00	11448	32.0827	6/21/2055 0:00	11494	31.2147	8/6/2055 0:00	11540	30.4209
3/22/2055 0:00	11403	33.0177	5/7/2055 0:00	11449	32.063	6/22/2055 0:00	11495	31.1967	8/7/2055 0:00	11541	30.4043
3/23/2055 0:00	11404	32.9959	5/8/2055 0:00	11450	32.0433	6/23/2055 0:00	11496	31.1787	8/8/2055 0:00	11542	30.3878
3/24/2055 0:00	11405	32.9741	5/9/2055 0:00	11451	32.0236	6/24/2055 0:00	11497	31.1608	8/9/2055 0:00	11543	30.3714
3/25/2055 0:00	11406	32.9524	5/10/2055 0:00	11452	32.004	6/25/2055 0:00	11498	31.1429	8/10/2055 0:00	11544	30.3549
3/26/2055 0:00	11407	32.9307	5/11/2055 0:00	11453	31.9844	6/26/2055 0:00	11499	31.125	8/11/2055 0:00	11545	30.3385
3/27/2055 0:00	11408	32.9091	5/12/2055 0:00	11454	31.9648	6/27/2055 0:00	11500	31.1072	8/12/2055 0:00	11546	30.3222
3/28/2055 0:00	11409	32.8876	5/13/2055 0:00	11455	31.9453	6/28/2055 0:00	11501	31.0894	8/13/2055 0:00	11547	30.3058
3/29/2055 0:00	11410	32.866	5/14/2055 0:00	11456	31.9259	6/29/2055 0:00	11502	31.0717	8/14/2055 0:00	11548	30.2895
3/30/2055 0:00	11411	32.8446	5/15/2055 0:00	11457	31.9064	6/30/2055 0:00	11503	31.0539	8/15/2055 0:00	11549	30.2732
3/31/2055 0:00	11412	32.8231	5/16/2055 0:00	11458	31.8871	7/1/2055 0:00	11504	31.0362	8/16/2055 0:00	11550	30.257
4/1/2055 0:00	11413	32.8018	5/17/2055 0:00	11459	31.8677	7/2/2055 0:00	11505	31.0186	8/17/2055 0:00	11551	30.2407
4/2/2055 0:00	11414	32.7804	5/18/2055 0:00	11460	31.8484	7/3/2055 0:00	11506	31.001	8/18/2055 0:00	11552	30.2245
4/3/2055 0:00	11415	32.7592	5/19/2055 0:00	11461	31.8291	7/4/2055 0:00	11507	30.9834	8/19/2055 0:00	11553	30.2083
4/4/2055 0:00	11416	32.7379	5/20/2055 0:00	11462	31.8099	7/5/2055 0:00	11508	30.9658	8/20/2055 0:00	11554	30.1922
4/5/2055 0:00	11417	32.7167	5/21/2055 0:00	11463	31.7907	7/6/2055 0:00	11509	30.9483	8/21/2055 0:00	11555	30.1761
4/6/2055 0:00	11418	32.6956	5/22/2055 0:00	11464	31.7716	7/7/2055 0:00	11510	30.9308	8/22/2055 0:00	11556	30.16
4/7/2055 0:00	11419	32.6745	5/23/2055 0:00	11465	31.7525	7/8/2055 0:00	11511	30.9133	8/23/2055 0:00	11557	30.1439
4/8/2055 0:00	11420	32.6535	5/24/2055 0:00	11466	31.7334	7/9/2055 0:00	11512	30.8959	8/24/2055 0:00	11558	30.1279
4/9/2055 0:00	11421	32.6325	5/25/2055 0:00	11467	31.7144	7/10/2055 0:00	11513	30.8785	8/25/2055 0:00	11559	30.1119
4/10/2055 0:00	11422	32.6116	5/26/2055 0:00	11468	31.6954	7/11/2055 0:00	11514	30.8612	8/26/2055 0:00	11560	30.0959
4/11/2055 0:00	11423	32.5907	5/27/2055 0:00	11469	31.6764	7/12/2055 0:00	11515	30.8438	8/27/2055 0:00	11561	30.08
4/12/2055 0:00	11424	32.5698	5/28/2055 0:00	11470	31.6575	7/13/2055 0:00	11516	30.8265	8/28/2055 0:00	11562	30.064
4/13/2055 0:00	11425	32.549	5/29/2055 0:00	11471	31.6386	7/14/2055 0:00	11517	30.8093	8/29/2055 0:00	11563	30.0481
4/14/2055 0:00	11426	32.5282	5/30/2055 0:00	11472	31.6198	7/15/2055 0:00	11518	30.792	8/30/2055 0:00	11564	30.0323
4/15/2055 0:00	11427	32.5075	5/31/2055 0:00	11473	31.601	7/16/2055 0:00	11519	30.7748	8/31/2055 0:00	11565	30.0164
4/16/2055 0:00	11428	32.4868	6/1/2055 0:00	11474	31.5822	7/17/2055 0:00	11520	30.7577	9/1/2055 0:00	11566	30.0006
4/17/2055 0:00	11429	32.4662	6/2/2055 0:00	11475	31.5635	7/18/2055 0:00	11521	30.7405	9/2/2055 0:00	11567	29.9848
4/18/2055 0:00	11430	32.4456	6/3/2055 0:00	11476	31.5448	7/19/2055 0:00	11522	30.7234	9/3/2055 0:00	11568	29.9691
4/19/2055 0:00	11431	32.4251	6/4/2055 0:00	11477	31.5262	7/20/2055 0:00	11523	30.7064	9/4/2055 0:00	11569	29.9534
4/20/2055 0:00	11432	32.4046	6/5/2055 0:00	11478	31.5075	7/21/2055 0:00	11524	30.6893	9/5/2055 0:00	11570	29.9377
4/21/2055 0:00	11433	32.3842	6/6/2055 0:00	11479	31.489	7/22/2055 0:00	11525	30.6723	9/6/2055 0:00	11571	29.922
4/22/2055 0:00	11434	32.3638	6/7/2055 0:00	11480	31.4704	7/23/2055 0:00	11526	30.6553	9/7/2055 0:00	11572	29.9063
4/23/2055 0:00	11435	32.3434	6/8/2055 0:00	11481	31.4519	7/24/2055 0:00	11527	30.6384	9/8/2055 0:00	11573	29.8907
4/24/2055 0:00	11436	32.3231	6/9/2055 0:00	11482	31.4335	7/25/2055 0:00	11528	30.6215	9/9/2055 0:00	11574	29.8751
4/25/2055 0:00	11437	32.3028	6/10/2055 0:00	11483	31.415	7/26/2055 0:00	11529	30.6046	9/10/2055 0:00	11575	29.8595
4/26/2055 0:00	11438	32.2826	6/11/2055 0:00	11484	31.3966	7/27/2055 0:00	11530	30.5877	9/11/2055 0:00	11576	29.844
4/27/2055 0:00	11439	32.2624	6/12/2055 0:00	11485	31.3783	7/28/2055 0:00	11531	30.5709	9/12/2055 0:00	11577	29.8285
4/28/2055 0:00	11440	32.2423	6/13/2055 0:00	11486	31.36	7/29/2055 0:00	11532	30.5541	9/13/2055 0:00	11578	29.813
4/29/2055 0:00	11441	32.2222	6/14/2055 0:00	11487	31.3417	7/30/2055 0:00	11533	30.5373	9/14/2055 0:00	11579	29.7975

9/15/2055 0:00	11580	29.7821	10/31/2055 0:00	11626	29.0987	12/16/2055 0:00	11672	28.463	1/31/2056 0:00	11718	27.8693
9/16/2055 0:00	11581	29.7667	11/1/2055 0:00	11627	29.0844	12/17/2055 0:00	11673	28.4497	2/1/2056 0:00	11719	27.8568
9/17/2055 0:00	11582	29.7513	11/2/2055 0:00	11628	29.0701	12/18/2055 0:00	11674	28.4364	2/2/2056 0:00	11720	27.8443
9/18/2055 0:00	11583	29.7359	11/3/2055 0:00	11629	29.0558	12/19/2055 0:00	11675	28.4231	2/3/2056 0:00	11721	27.8319
9/19/2055 0:00	11584	29.7206	11/4/2055 0:00	11630	29.0416	12/20/2055 0:00	11676	28.4098	2/4/2056 0:00	11722	27.8195
9/20/2055 0:00	11585	29.7053	11/5/2055 0:00	11631	29.0274	12/21/2055 0:00	11677	28.3966	2/5/2056 0:00	11723	27.807
9/21/2055 0:00	11586	29.69	11/6/2055 0:00	11632	29.0132	12/22/2055 0:00	11678	28.3833	2/6/2056 0:00	11724	27.7946
9/22/2055 0:00	11587	29.6747	11/7/2055 0:00	11633	28.999	12/23/2055 0:00	11679	28.3701	2/7/2056 0:00	11725	27.7823
9/23/2055 0:00	11588	29.6595	11/8/2055 0:00	11634	28.9849	12/24/2055 0:00	11680	28.3569	2/8/2056 0:00	11726	27.7699
9/24/2055 0:00	11589	29.6443	11/9/2055 0:00	11635	28.9707	12/25/2055 0:00	11681	28.3438	2/9/2056 0:00	11727	27.7576
9/25/2055 0:00	11590	29.6291	11/10/2055 0:00	11636	28.9566	12/26/2055 0:00	11682	28.3306	2/10/2056 0:00	11728	27.7452
9/26/2055 0:00	11591	29.6139	11/11/2055 0:00	11637	28.9426	12/27/2055 0:00	11683	28.3175	2/11/2056 0:00	11729	27.7329
9/27/2055 0:00	11592	29.5988	11/12/2055 0:00	11638	28.9285	12/28/2055 0:00	11684	28.3043	2/12/2056 0:00	11730	27.7206
9/28/2055 0:00	11593	29.5837	11/13/2055 0:00	11639	28.9145	12/29/2055 0:00	11685	28.2912	2/13/2056 0:00	11731	27.7084
9/29/2055 0:00	11594	29.5686	11/14/2055 0:00	11640	28.9005	12/30/2055 0:00	11686	28.2782	2/14/2056 0:00	11732	27.6961
9/30/2055 0:00	11595	29.5536	11/15/2055 0:00	11641	28.8865	12/31/2055 0:00	11687	28.2651	2/15/2056 0:00	11733	27.6839
10/1/2055 0:00	11596	29.5385	11/16/2055 0:00	11642	28.8725	1/1/2056 0:00	11688	28.252	2/16/2056 0:00	11734	27.6716
10/2/2055 0:00	11597	29.5235	11/17/2055 0:00	11643	28.8585	1/2/2056 0:00	11689	28.239	2/17/2056 0:00	11735	27.6594
10/3/2055 0:00	11598	29.5085	11/18/2055 0:00	11644	28.8446	1/3/2056 0:00	11690	28.226	2/18/2056 0:00	11736	27.6472
10/4/2055 0:00	11599	29.4936	11/19/2055 0:00	11645	28.8307	1/4/2056 0:00	11691	28.213	2/19/2056 0:00	11737	27.6351
10/5/2055 0:00	11600	29.4786	11/20/2055 0:00	11646	28.8168	1/5/2056 0:00	11692	28.2001	2/20/2056 0:00	11738	27.6229
10/6/2055 0:00	11601	29.4637	11/21/2055 0:00	11647	28.8029	1/6/2056 0:00	11693	28.1871	2/21/2056 0:00	11739	27.6107
10/7/2055 0:00	11602	29.4488	11/22/2055 0:00	11648	28.7891	1/7/2056 0:00	11694	28.1742	2/22/2056 0:00	11740	27.5986
10/8/2055 0:00	11603	29.434	11/23/2055 0:00	11649	28.7753	1/8/2056 0:00	11695	28.1613	2/23/2056 0:00	11741	27.5865
10/9/2055 0:00	11604	29.4191	11/24/2055 0:00	11650	28.7615	1/9/2056 0:00	11696	28.1484	2/24/2056 0:00	11742	27.5744
10/10/2055 0:00	11605	29.4043	11/25/2055 0:00	11651	28.7477	1/10/2056 0:00	11697	28.1355	2/25/2056 0:00	11743	27.5623
10/11/2055 0:00	11606	29.3895	11/26/2055 0:00	11652	28.7339	1/11/2056 0:00	11698	28.1226	2/26/2056 0:00	11744	27.5503
10/12/2055 0:00	11607	29.3748	11/27/2055 0:00	11653	28.7202	1/12/2056 0:00	11699	28.1098	2/27/2056 0:00	11745	27.5382
10/13/2055 0:00	11608	29.36	11/28/2055 0:00	11654	28.7065	1/13/2056 0:00	11700	28.097	2/28/2056 0:00	11746	27.5262
10/14/2055 0:00	11609	29.3453	11/29/2055 0:00	11655	28.6928	1/14/2056 0:00	11701	28.0842	2/29/2056 0:00	11747	27.5142
10/15/2055 0:00	11610	29.3306	11/30/2055 0:00	11656	28.6791	1/15/2056 0:00	11702	28.0714	3/1/2056 0:00	11748	27.5022
10/16/2055 0:00	11611	29.3159	12/1/2055 0:00	11657	28.6655	1/16/2056 0:00	11703	28.0586	3/2/2056 0:00	11749	27.4902
10/17/2055 0:00	11612	29.3013	12/2/2055 0:00	11658	28.6518	1/17/2056 0:00	11704	28.0459	3/3/2056 0:00	11750	27.4783
10/18/2055 0:00	11613	29.2867	12/3/2055 0:00	11659	28.6382	1/18/2056 0:00	11705	28.0331	3/4/2056 0:00	11751	27.4663
10/19/2055 0:00	11614	29.2721	12/4/2055 0:00	11660	28.6246	1/19/2056 0:00	11706	28.0204	3/5/2056 0:00	11752	27.4544
10/20/2055 0:00	11615	29.2575	12/5/2055 0:00	11661	28.611	1/20/2056 0:00	11707	28.0077	3/6/2056 0:00	11753	27.4425
10/21/2055 0:00	11616	29.2429	12/6/2055 0:00	11662	28.5975	1/21/2056 0:00	11708	27.9951	3/7/2056 0:00	11754	27.4306
10/22/2055 0:00	11617	29.2284	12/7/2055 0:00	11663	28.5839	1/22/2056 0:00	11709	27.9824	3/8/2056 0:00	11755	27.4187
10/23/2055 0:00	11618	29.2139	12/8/2055 0:00	11664	28.5704	1/23/2056 0:00	11710	27.9698	3/9/2056 0:00	11756	27.4068
10/24/2055 0:00	11619	29.1994	12/9/2055 0:00	11665	28.5569	1/24/2056 0:00	11711	27.9571	3/10/2056 0:00	11757	27.395
10/25/2055 0:00	11620	29.1849	12/10/2055 0:00	11666	28.5435	1/25/2056 0:00	11712	27.9445	3/11/2056 0:00	11758	27.3831
10/26/2055 0:00	11621	29.1705	12/11/2055 0:00	11667	28.53	1/26/2056 0:00	11713	27.9319	3/12/2056 0:00	11759	27.3713
10/27/2055 0:00	11622	29.1561	12/12/2055 0:00	11668	28.5166	1/27/2056 0:00	11714	27.9194	3/13/2056 0:00	11760	27.3595
10/28/2055 0:00	11623	29.1417	12/13/2055 0:00	11669	28.5032	1/28/2056 0:00	11715	27.9068	3/14/2056 0:00	11761	27.3477
10/29/2055 0:00	11624	29.1273	12/14/2055 0:00	11670	28.4898	1/29/2056 0:00	11716	27.8943	3/15/2056 0:00	11762	27.3359
10/30/2055 0:00	11625	29.113	12/15/2055 0:00	11671	28.4764	1/30/2056 0:00	11717	27.8818	3/16/2056 0:00	11763	27.3242

3/17/2056 0:00	11764	27.3124	5/2/2056 0:00	11810	26.7884	6/17/2056 0:00	11856	26.2938	8/2/2056 0:00	11902	25.8256
3/18/2056 0:00	11765	27.3007	5/3/2056 0:00	11811	26.7774	6/18/2056 0:00	11857	26.2833	8/3/2056 0:00	11903	25.8157
3/19/2056 0:00	11766	27.289	5/4/2056 0:00	11812	26.7663	6/19/2056 0:00	11858	26.2729	8/4/2056 0:00	11904	25.8058
3/20/2056 0:00	11767	27.2773	5/5/2056 0:00	11813	26.7553	6/20/2056 0:00	11859	26.2625	8/5/2056 0:00	11905	25.7959
3/21/2056 0:00	11768	27.2656	5/6/2056 0:00	11814	26.7443	6/21/2056 0:00	11860	26.252	8/6/2056 0:00	11906	25.786
3/22/2056 0:00	11769	27.254	5/7/2056 0:00	11815	26.7333	6/22/2056 0:00	11861	26.2416	8/7/2056 0:00	11907	25.7761
3/23/2056 0:00	11770	27.2423	5/8/2056 0:00	11816	26.7223	6/23/2056 0:00	11862	26.2313	8/8/2056 0:00	11908	25.7663
3/24/2056 0:00	11771	27.2307	5/9/2056 0:00	11817	26.7113	6/24/2056 0:00	11863	26.2209	8/9/2056 0:00	11909	25.7565
3/25/2056 0:00	11772	27.219	5/10/2056 0:00	11818	26.7004	6/25/2056 0:00	11864	26.2105	8/10/2056 0:00	11910	25.7466
3/26/2056 0:00	11773	27.2074	5/11/2056 0:00	11819	26.6894	6/26/2056 0:00	11865	26.2002	8/11/2056 0:00	11911	25.7368
3/27/2056 0:00	11774	27.1959	5/12/2056 0:00	11820	26.6785	6/27/2056 0:00	11866	26.1898	8/12/2056 0:00	11912	25.727
3/28/2056 0:00	11775	27.1843	5/13/2056 0:00	11821	26.6676	6/28/2056 0:00	11867	26.1795	8/13/2056 0:00	11913	25.7172
3/29/2056 0:00	11776	27.1727	5/14/2056 0:00	11822	26.6567	6/29/2056 0:00	11868	26.1692	8/14/2056 0:00	11914	25.7074
3/30/2056 0:00	11777	27.1612	5/15/2056 0:00	11823	26.6458	6/30/2056 0:00	11869	26.1589	8/15/2056 0:00	11915	25.6977
3/31/2056 0:00	11778	27.1496	5/16/2056 0:00	11824	26.6349	7/1/2056 0:00	11870	26.1486	8/16/2056 0:00	11916	25.6879
4/1/2056 0:00	11779	27.1381	5/17/2056 0:00	11825	26.624	7/2/2056 0:00	11871	26.1383	8/17/2056 0:00	11917	25.6782
4/2/2056 0:00	11780	27.1266	5/18/2056 0:00	11826	26.6132	7/3/2056 0:00	11872	26.1281	8/18/2056 0:00	11918	25.6684
4/3/2056 0:00	11781	27.1151	5/19/2056 0:00	11827	26.6024	7/4/2056 0:00	11873	26.1178	8/19/2056 0:00	11919	25.6587
4/4/2056 0:00	11782	27.1037	5/20/2056 0:00	11828	26.5915	7/5/2056 0:00	11874	26.1076	8/20/2056 0:00	11920	25.649
4/5/2056 0:00	11783	27.0922	5/21/2056 0:00	11829	26.5807	7/6/2056 0:00	11875	26.0973	8/21/2056 0:00	11921	25.6393
4/6/2056 0:00	11784	27.0808	5/22/2056 0:00	11830	26.5699	7/7/2056 0:00	11876	26.0871	8/22/2056 0:00	11922	25.6296
4/7/2056 0:00	11785	27.0694	5/23/2056 0:00	11831	26.5591	7/8/2056 0:00	11877	26.0769	8/23/2056 0:00	11923	25.6199
4/8/2056 0:00	11786	27.0579	5/24/2056 0:00	11832	26.5484	7/9/2056 0:00	11878	26.0667	8/24/2056 0:00	11924	25.6102
4/9/2056 0:00	11787	27.0465	5/25/2056 0:00	11833	26.5376	7/10/2056 0:00	11879	26.0565	8/25/2056 0:00	11925	25.6006
4/10/2056 0:00	11788	27.0352	5/26/2056 0:00	11834	26.5269	7/11/2056 0:00	11880	26.0464	8/26/2056 0:00	11926	25.5909
4/11/2056 0:00	11789	27.0238	5/27/2056 0:00	11835	26.5161	7/12/2056 0:00	11881	26.0362	8/27/2056 0:00	11927	25.5813
4/12/2056 0:00	11790	27.0124	5/28/2056 0:00	11836	26.5054	7/13/2056 0:00	11882	26.026	8/28/2056 0:00	11928	25.5716
4/13/2056 0:00	11791	27.0011	5/29/2056 0:00	11837	26.4947	7/14/2056 0:00	11883	26.0159	8/29/2056 0:00	11929	25.562
4/14/2056 0:00	11792	26.9898	5/30/2056 0:00	11838	26.484	7/15/2056 0:00	11884	26.0058	8/30/2056 0:00	11930	25.5524
4/15/2056 0:00	11793	26.9785	5/31/2056 0:00	11839	26.4733	7/16/2056 0:00	11885	25.9957	8/31/2056 0:00	11931	25.5428
4/16/2056 0:00	11794	26.9672	6/1/2056 0:00	11840	26.4627	7/17/2056 0:00	11886	25.9856	9/1/2056 0:00	11932	25.5332
4/17/2056 0:00	11795	26.9559	6/2/2056 0:00	11841	26.452	7/18/2056 0:00	11887	25.9755	9/2/2056 0:00	11933	25.5237
4/18/2056 0:00	11796	26.9446	6/3/2056 0:00	11842	26.4414	7/19/2056 0:00	11888	25.9654	9/3/2056 0:00	11934	25.5141
4/19/2056 0:00	11797	26.9334	6/4/2056 0:00	11843	26.4308	7/20/2056 0:00	11889	25.9554	9/4/2056 0:00	11935	25.5045
4/20/2056 0:00	11798	26.9222	6/5/2056 0:00	11844	26.4201	7/21/2056 0:00	11890	25.9453	9/5/2056 0:00	11936	25.495
4/21/2056 0:00	11799	26.9109	6/6/2056 0:00	11845	26.4095	7/22/2056 0:00	11891	25.9353	9/6/2056 0:00	11937	25.4855
4/22/2056 0:00	11800	26.8997	6/7/2056 0:00	11846	26.399	7/23/2056 0:00	11892	25.9252	9/7/2056 0:00	11938	25.4759
4/23/2056 0:00	11801	26.8885	6/8/2056 0:00	11847	26.3884	7/24/2056 0:00	11893	25.9152	9/8/2056 0:00	11939	25.4664
4/24/2056 0:00	11802	26.8773	6/9/2056 0:00	11848	26.3778	7/25/2056 0:00	11894	25.9052	9/9/2056 0:00	11940	25.4569
4/25/2056 0:00	11803	26.8662	6/10/2056 0:00	11849	26.3673	7/26/2056 0:00	11895	25.8952	9/10/2056 0:00	11941	25.4474
4/26/2056 0:00	11804	26.855	6/11/2056 0:00	11850	26.3567	7/27/2056 0:00	11896	25.8852	9/11/2056 0:00	11942	25.4379
4/27/2056 0:00	11805	26.8439	6/12/2056 0:00	11851	26.3462	7/28/2056 0:00	11897	25.8752	9/12/2056 0:00	11943	25.4285
4/28/2056 0:00	11806	26.8328	6/13/2056 0:00	11852	26.3357	7/29/2056 0:00	11898	25.8653	9/13/2056 0:00	11944	25.419
4/29/2056 0:00	11807	26.8217	6/14/2056 0:00	11853	26.3252	7/30/2056 0:00	11899	25.8553	9/14/2056 0:00	11945	25.4096
4/30/2056 0:00	11808	26.8106	6/15/2056 0:00	11854	26.3147	7/31/2056 0:00	11900	25.8454	9/15/2056 0:00	11946	25.4001
5/1/2056 0:00	11809	26.7995	6/16/2056 0:00	11855	26.3042	8/1/2056 0:00	11901	25.8355	9/16/2056 0:00	11947	25.3907

9/17/2056 0:00	11948	25.3813	11/2/2056 0:00	11994	24.9587	12/18/2056 0:00	12040	24.556	2/2/2057 0:00	12086	24.1714
9/18/2056 0:00	11949	25.3719	11/3/2056 0:00	11995	24.9497	12/19/2056 0:00	12041	24.5474	2/3/2057 0:00	12087	24.1633
9/19/2056 0:00	11950	25.3625	11/4/2056 0:00	11996	24.9408	12/20/2056 0:00	12042	24.5389	2/4/2057 0:00	12088	24.1551
9/20/2056 0:00	11951	25.3531	11/5/2056 0:00	11997	24.9319	12/21/2056 0:00	12043	24.5304	2/5/2057 0:00	12089	24.147
9/21/2056 0:00	11952	25.3437	11/6/2056 0:00	11998	24.9229	12/22/2056 0:00	12044	24.5218	2/6/2057 0:00	12090	24.1388
9/22/2056 0:00	11953	25.3343	11/7/2056 0:00	11999	24.914	12/23/2056 0:00	12045	24.5133	2/7/2057 0:00	12091	24.1307
9/23/2056 0:00	11954	25.325	11/8/2056 0:00	12000	24.9051	12/24/2056 0:00	12046	24.5048	2/8/2057 0:00	12092	24.1226
9/24/2056 0:00	11955	25.3156	11/9/2056 0:00	12001	24.8962	12/25/2056 0:00	12047	24.4963	2/9/2057 0:00	12093	24.1144
9/25/2056 0:00	11956	25.3063	11/10/2056 0:00	12002	24.8873	12/26/2056 0:00	12048	24.4878	2/10/2057 0:00	12094	24.1063
9/26/2056 0:00	11957	25.2969	11/11/2056 0:00	12003	24.8784	12/27/2056 0:00	12049	24.4794	2/11/2057 0:00	12095	24.0982
9/27/2056 0:00	11958	25.2876	11/12/2056 0:00	12004	24.8695	12/28/2056 0:00	12050	24.4709	2/12/2057 0:00	12096	24.0901
9/28/2056 0:00	11959	25.2783	11/13/2056 0:00	12005	24.8607	12/29/2056 0:00	12051	24.4624	2/13/2057 0:00	12097	24.082
9/29/2056 0:00	11960	25.269	11/14/2056 0:00	12006	24.8518	12/30/2056 0:00	12052	24.454	2/14/2057 0:00	12098	24.0739
9/30/2056 0:00	11961	25.2597	11/15/2056 0:00	12007	24.843	12/31/2056 0:00	12053	24.4455	2/15/2057 0:00	12099	24.0659
10/1/2056 0:00	11962	25.2504	11/16/2056 0:00	12008	24.8341	1/1/2057 0:00	12054	24.4371	2/16/2057 0:00	12100	24.0578
10/2/2056 0:00	11963	25.2412	11/17/2056 0:00	12009	24.8253	1/2/2057 0:00	12055	24.4287	2/17/2057 0:00	12101	24.0497
10/3/2056 0:00	11964	25.2319	11/18/2056 0:00	12010	24.8165	1/3/2057 0:00	12056	24.4202	2/18/2057 0:00	12102	24.0417
10/4/2056 0:00	11965	25.2227	11/19/2056 0:00	12011	24.8077	1/4/2057 0:00	12057	24.4118	2/19/2057 0:00	12103	24.0336
10/5/2056 0:00	11966	25.2134	11/20/2056 0:00	12012	24.7988	1/5/2057 0:00	12058	24.4034	2/20/2057 0:00	12104	24.0256
10/6/2056 0:00	11967	25.2042	11/21/2056 0:00	12013	24.7901	1/6/2057 0:00	12059	24.395	2/21/2057 0:00	12105	24.0176
10/7/2056 0:00	11968	25.195	11/22/2056 0:00	12014	24.7813	1/7/2057 0:00	12060	24.3867	2/22/2057 0:00	12106	24.0096
10/8/2056 0:00	11969	25.1858	11/23/2056 0:00	12015	24.7725	1/8/2057 0:00	12061	24.3783	2/23/2057 0:00	12107	24.0015
10/9/2056 0:00	11970	25.1766	11/24/2056 0:00	12016	24.7637	1/9/2057 0:00	12062	24.3699	2/24/2057 0:00	12108	23.9935
10/10/2056 0:00	11971	25.1674	11/25/2056 0:00	12017	24.755	1/10/2057 0:00	12063	24.3615	2/25/2057 0:00	12109	23.9855
10/11/2056 0:00	11972	25.1582	11/26/2056 0:00	12018	24.7462	1/11/2057 0:00	12064	24.3532	2/26/2057 0:00	12110	23.9775
10/12/2056 0:00	11973	25.149	11/27/2056 0:00	12019	24.7375	1/12/2057 0:00	12065	24.3448	2/27/2057 0:00	12111	23.9696
10/13/2056 0:00	11974	25.1399	11/28/2056 0:00	12020	24.7288	1/13/2057 0:00	12066	24.3365	2/28/2057 0:00	12112	23.9616
10/14/2056 0:00	11975	25.1307	11/29/2056 0:00	12021	24.72	1/14/2057 0:00	12067	24.3282	3/1/2057 0:00	12113	23.9536
10/15/2056 0:00	11976	25.1216	11/30/2056 0:00	12022	24.7113	1/15/2057 0:00	12068	24.3199	3/2/2057 0:00	12114	23.9457
10/16/2056 0:00	11977	25.1125	12/1/2056 0:00	12023	24.7026	1/16/2057 0:00	12069	24.3115	3/3/2057 0:00	12115	23.9377
10/17/2056 0:00	11978	25.1033	12/2/2056 0:00	12024	24.6939	1/17/2057 0:00	12070	24.3032	3/4/2057 0:00	12116	23.9298
10/18/2056 0:00	11979	25.0942	12/3/2056 0:00	12025	24.6852	1/18/2057 0:00	12071	24.2949	3/5/2057 0:00	12117	23.9218
10/19/2056 0:00	11980	25.0851	12/4/2056 0:00	12026	24.6766	1/19/2057 0:00	12072	24.2866	3/6/2057 0:00	12118	23.9139
10/20/2056 0:00	11981	25.076	12/5/2056 0:00	12027	24.6679	1/20/2057 0:00	12073	24.2784	3/7/2057 0:00	12119	23.906
10/21/2056 0:00	11982	25.0669	12/6/2056 0:00	12028	24.6592	1/21/2057 0:00	12074	24.2701	3/8/2057 0:00	12120	23.8981
10/22/2056 0:00	11983	25.0579	12/7/2056 0:00	12029	24.6506	1/22/2057 0:00	12075	24.2618	3/9/2057 0:00	12121	23.8901
10/23/2056 0:00	11984	25.0488	12/8/2056 0:00	12030	24.6419	1/23/2057 0:00	12076	24.2536	3/10/2057 0:00	12122	23.8822
10/24/2056 0:00	11985	25.0398	12/9/2056 0:00	12031	24.6333	1/24/2057 0:00	12077	24.2453	3/11/2057 0:00	12123	23.8744
10/25/2056 0:00	11986	25.0307	12/10/2056 0:00	12032	24.6247	1/25/2057 0:00	12078	24.2371	3/12/2057 0:00	12124	23.8665
10/26/2056 0:00	11987	25.0217	12/11/2056 0:00	12033	24.6161	1/26/2057 0:00	12079	24.2289	3/13/2057 0:00	12125	23.8586
10/27/2056 0:00	11988	25.0127	12/12/2056 0:00	12034	24.6074	1/27/2057 0:00	12080	24.2206	3/14/2057 0:00	12126	23.8507
10/28/2056 0:00	11989	25.0036	12/13/2056 0:00	12035	24.5988	1/28/2057 0:00	12081	24.2124	3/15/2057 0:00	12127	23.8429
10/29/2056 0:00	11990	24.9946	12/14/2056 0:00	12036	24.5903	1/29/2057 0:00	12082	24.2042	3/16/2057 0:00	12128	23.835
10/30/2056 0:00	11991	24.9856	12/15/2056 0:00	12037	24.5817	1/30/2057 0:00	12083	24.196	3/17/2057 0:00	12129	23.8271
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3/21/2057 0:00	12133	23.7958	5/6/2057 0:00	12179	23.4438	6/21/2057 0:00	12225	23.106	8/6/2057 0:00	12271	22.7814
3/22/2057 0:00	12134	23.788	5/7/2057 0:00	12180	23.4363	6/22/2057 0:00	12226	23.0988	8/7/2057 0:00	12272	22.7745
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3/24/2057 0:00	12136	23.7724	5/9/2057 0:00	12182	23.4213	6/24/2057 0:00	12228	23.0844	8/9/2057 0:00	12274	22.7607
3/25/2057 0:00	12137	23.7646	5/10/2057 0:00	12183	23.4138	6/25/2057 0:00	12229	23.0772	8/10/2057 0:00	12275	22.7538
3/26/2057 0:00	12138	23.7568	5/11/2057 0:00	12184	23.4064	6/26/2057 0:00	12230	23.0701	8/11/2057 0:00	12276	22.7469
3/27/2057 0:00	12139	23.7491	5/12/2057 0:00	12185	23.3989	6/27/2057 0:00	12231	23.0629	8/12/2057 0:00	12277	22.74
3/28/2057 0:00	12140	23.7413	5/13/2057 0:00	12186	23.3915	6/28/2057 0:00	12232	23.0557	8/13/2057 0:00	12278	22.7331
3/29/2057 0:00	12141	23.7335	5/14/2057 0:00	12187	23.384	6/29/2057 0:00	12233	23.0486	8/14/2057 0:00	12279	22.7262
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3/31/2057 0:00	12143	23.718	5/16/2057 0:00	12189	23.3692	7/1/2057 0:00	12235	23.0343	8/16/2057 0:00	12281	22.7125
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4/3/2057 0:00	12146	23.6948	5/19/2057 0:00	12192	23.3469	7/4/2057 0:00	12238	23.0129	8/19/2057 0:00	12284	22.692
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4/5/2057 0:00	12148	23.6794	5/21/2057 0:00	12194	23.3321	7/6/2057 0:00	12240	22.9987	8/21/2057 0:00	12286	22.6783
4/6/2057 0:00	12149	23.6717	5/22/2057 0:00	12195	23.3247	7/7/2057 0:00	12241	22.9916	8/22/2057 0:00	12287	22.6715
4/7/2057 0:00	12150	23.664	5/23/2057 0:00	12196	23.3173	7/8/2057 0:00	12242	22.9845	8/23/2057 0:00	12288	22.6646
4/8/2057 0:00	12151	23.6563	5/24/2057 0:00	12197	23.3099	7/9/2057 0:00	12243	22.9774	8/24/2057 0:00	12289	22.6578
4/9/2057 0:00	12152	23.6486	5/25/2057 0:00	12198	23.3026	7/10/2057 0:00	12244	22.9704	8/25/2057 0:00	12290	22.651
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4/13/2057 0:00	12156	23.6179	5/29/2057 0:00	12202	23.2732	7/14/2057 0:00	12248	22.9421	8/29/2057 0:00	12294	22.6238
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4/17/2057 0:00	12160	23.5874	6/2/2057 0:00	12206	23.2438	7/18/2057 0:00	12252	22.9139	9/2/2057 0:00	12298	22.5967
4/18/2057 0:00	12161	23.5798	6/3/2057 0:00	12207	23.2365	7/19/2057 0:00	12253	22.9069	9/3/2057 0:00	12299	22.5899
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4/21/2057 0:00	12164	23.5569	6/6/2057 0:00	12210	23.2146	7/22/2057 0:00	12256	22.8858	9/6/2057 0:00	12302	22.5697
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4/23/2057 0:00	12166	23.5418	6/8/2057 0:00	12212	23.2	7/24/2057 0:00	12258	22.8718	9/8/2057 0:00	12304	22.5562
4/24/2057 0:00	12167	23.5342	6/9/2057 0:00	12213	23.1928	7/25/2057 0:00	12259	22.8649	9/9/2057 0:00	12305	22.5495
4/25/2057 0:00	12168	23.5266	6/10/2057 0:00	12214	23.1855	7/26/2057 0:00	12260	22.8579	9/10/2057 0:00	12306	22.5428
4/26/2057 0:00	12169	23.519	6/11/2057 0:00	12215	23.1782	7/27/2057 0:00	12261	22.8509	9/11/2057 0:00	12307	22.536
4/27/2057 0:00	12170	23.5115	6/12/2057 0:00	12216	23.171	7/28/2057 0:00	12262	22.8439	9/12/2057 0:00	12308	22.5293
4/28/2057 0:00	12171	23.5039	6/13/2057 0:00	12217	23.1637	7/29/2057 0:00	12263	22.8369	9/13/2057 0:00	12309	22.5226
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5/2/2057 0:00	12175	23.4738	6/17/2057 0:00	12221	23.1348	8/2/2057 0:00	12267	22.8091	9/17/2057 0:00	12313	22.4959
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5/4/2057 0:00	12177	23.4588	6/19/2057 0:00	12223	23.1204	8/4/2057 0:00	12269	22.7953	9/19/2057 0:00	12315	22.4825

9/20/2057 0:00	12316	22.4758	11/5/2057 0:00	12362	22.1748	12/21/2057 0:00	12408	21.8846	2/5/2058 0:00	12454	21.6045
9/21/2057 0:00	12317	22.4692	11/6/2057 0:00	12363	22.1684	12/22/2057 0:00	12409	21.8784	2/6/2058 0:00	12455	21.5985
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9/23/2057 0:00	12319	22.4559	11/8/2057 0:00	12365	22.1556	12/24/2057 0:00	12411	21.866	2/8/2058 0:00	12457	21.5865
9/24/2057 0:00	12320	22.4492	11/9/2057 0:00	12366	22.1492	12/25/2057 0:00	12412	21.8599	2/9/2058 0:00	12458	21.5806
9/25/2057 0:00	12321	22.4426	11/10/2057 0:00	12367	22.1428	12/26/2057 0:00	12413	21.8537	2/10/2058 0:00	12459	21.5746
9/26/2057 0:00	12322	22.4359	11/11/2057 0:00	12368	22.1364	12/27/2057 0:00	12414	21.8475	2/11/2058 0:00	12460	21.5686
9/27/2057 0:00	12323	22.4293	11/12/2057 0:00	12369	22.13	12/28/2057 0:00	12415	21.8413	2/12/2058 0:00	12461	21.5627
9/28/2057 0:00	12324	22.4227	11/13/2057 0:00	12370	22.1236	12/29/2057 0:00	12416	21.8352	2/13/2058 0:00	12462	21.5567
9/29/2057 0:00	12325	22.4161	11/14/2057 0:00	12371	22.1172	12/30/2057 0:00	12417	21.829	2/14/2058 0:00	12463	21.5508
9/30/2057 0:00	12326	22.4094	11/15/2057 0:00	12372	22.1109	12/31/2057 0:00	12418	21.8229	2/15/2058 0:00	12464	21.5448
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10/4/2057 0:00	12330	22.383	11/19/2057 0:00	12376	22.0854	1/4/2058 0:00	12422	21.7983	2/19/2058 0:00	12468	21.5211
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10/6/2057 0:00	12332	22.3699	11/21/2057 0:00	12378	22.0727	1/6/2058 0:00	12424	21.7861	2/21/2058 0:00	12470	21.5093
10/7/2057 0:00	12333	22.3633	11/22/2057 0:00	12379	22.0664	1/7/2058 0:00	12425	21.7799	2/22/2058 0:00	12471	21.5034
10/8/2057 0:00	12334	22.3567	11/23/2057 0:00	12380	22.06	1/8/2058 0:00	12426	21.7738	2/23/2058 0:00	12472	21.4974
10/9/2057 0:00	12335	22.3502	11/24/2057 0:00	12381	22.0537	1/9/2058 0:00	12427	21.7677	2/24/2058 0:00	12473	21.4915
10/10/2057 0:00	12336	22.3436	11/25/2057 0:00	12382	22.0474	1/10/2058 0:00	12428	21.7616	2/25/2058 0:00	12474	21.4856
10/11/2057 0:00	12337	22.337	11/26/2057 0:00	12383	22.041	1/11/2058 0:00	12429	21.7555	2/26/2058 0:00	12475	21.4797
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10/15/2057 0:00	12341	22.3109	11/30/2057 0:00	12387	22.0158	1/15/2058 0:00	12433	21.7311	3/2/2058 0:00	12479	21.4562
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10/19/2057 0:00	12345	22.2848	12/4/2057 0:00	12391	21.9907	1/19/2058 0:00	12437	21.7069	3/6/2058 0:00	12483	21.4327
10/20/2057 0:00	12346	22.2783	12/5/2057 0:00	12392	21.9844	1/20/2058 0:00	12438	21.7008	3/7/2058 0:00	12484	21.4269
10/21/2057 0:00	12347	22.2718	12/6/2057 0:00	12393	21.9781	1/21/2058 0:00	12439	21.6947	3/8/2058 0:00	12485	21.421
10/22/2057 0:00	12348	22.2653	12/7/2057 0:00	12394	21.9718	1/22/2058 0:00	12440	21.6887	3/9/2058 0:00	12486	21.4152
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10/24/2057 0:00	12350	22.2523	12/9/2057 0:00	12396	21.9593	1/24/2058 0:00	12442	21.6766	3/11/2058 0:00	12488	21.4035
10/25/2057 0:00	12351	22.2458	12/10/2057 0:00	12397	21.9531	1/25/2058 0:00	12443	21.6706	3/12/2058 0:00	12489	21.3977
10/26/2057 0:00	12352	22.2393	12/11/2057 0:00	12398	21.9468	1/26/2058 0:00	12444	21.6645	3/13/2058 0:00	12490	21.3918
10/27/2057 0:00	12353	22.2329	12/12/2057 0:00	12399	21.9406	1/27/2058 0:00	12445	21.6585	3/14/2058 0:00	12491	21.386
10/28/2057 0:00	12354	22.2264	12/13/2057 0:00	12400	21.9343	1/28/2058 0:00	12446	21.6525	3/15/2058 0:00	12492	21.3802
10/29/2057 0:00	12355	22.2199	12/14/2057 0:00	12401	21.9281	1/29/2058 0:00	12447	21.6465	3/16/2058 0:00	12493	21.3744
10/30/2057 0:00	12356	22.2135	12/15/2057 0:00	12402	21.9219	1/30/2058 0:00	12448	21.6405	3/17/2058 0:00	12494	21.3686
10/31/2057 0:00	12357	22.207	12/16/2057 0:00	12403	21.9157	1/31/2058 0:00	12449	21.6344	3/18/2058 0:00	12495	21.3628
11/1/2057 0:00	12358	22.2006	12/17/2057 0:00	12404	21.9094	2/1/2058 0:00	12450	21.6284	3/19/2058 0:00	12496	21.357
11/2/2057 0:00	12359	22.1941	12/18/2057 0:00	12405	21.9032	2/2/2058 0:00	12451	21.6224	3/20/2058 0:00	12497	21.3512
11/3/2057 0:00	12360	22.1877	12/19/2057 0:00	12406	21.897	2/3/2058 0:00	12452	21.6164	3/21/2058 0:00	12498	21.3454
11/4/2057 0:00	12361	22.1813	12/20/2057 0:00	12407	21.8908	2/4/2058 0:00	12453	21.6104	3/22/2058 0:00	12499	21.3396

3/23/2058 0:00	12500	21.3338	5/8/2058 0:00	12546	21.072	6/23/2058 0:00	12592	20.8186	8/8/2058 0:00	12638	20.5731
3/24/2058 0:00	12501	21.328	5/9/2058 0:00	12547	21.0664	6/24/2058 0:00	12593	20.8132	8/9/2058 0:00	12639	20.5679
3/25/2058 0:00	12502	21.3222	5/10/2058 0:00	12548	21.0608	6/25/2058 0:00	12594	20.8078	8/10/2058 0:00	12640	20.5626
3/26/2058 0:00	12503	21.3164	5/11/2058 0:00	12549	21.0552	6/26/2058 0:00	12595	20.8024	8/11/2058 0:00	12641	20.5574
3/27/2058 0:00	12504	21.3107	5/12/2058 0:00	12550	21.0496	6/27/2058 0:00	12596	20.7969	8/12/2058 0:00	12642	20.5521
3/28/2058 0:00	12505	21.3049	5/13/2058 0:00	12551	21.0441	6/28/2058 0:00	12597	20.7915	8/13/2058 0:00	12643	20.5469
3/29/2058 0:00	12506	21.2991	5/14/2058 0:00	12552	21.0385	6/29/2058 0:00	12598	20.7861	8/14/2058 0:00	12644	20.5417
3/30/2058 0:00	12507	21.2934	5/15/2058 0:00	12553	21.0329	6/30/2058 0:00	12599	20.7807	8/15/2058 0:00	12645	20.5364
3/31/2058 0:00	12508	21.2876	5/16/2058 0:00	12554	21.0273	7/1/2058 0:00	12600	20.7754	8/16/2058 0:00	12646	20.5312
4/1/2058 0:00	12509	21.2819	5/17/2058 0:00	12555	21.0218	7/2/2058 0:00	12601	20.77	8/17/2058 0:00	12647	20.526
4/2/2058 0:00	12510	21.2761	5/18/2058 0:00	12556	21.0162	7/3/2058 0:00	12602	20.7646	8/18/2058 0:00	12648	20.5208
4/3/2058 0:00	12511	21.2704	5/19/2058 0:00	12557	21.0107	7/4/2058 0:00	12603	20.7592	8/19/2058 0:00	12649	20.5156
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4/5/2058 0:00	12513	21.2589	5/21/2058 0:00	12559	20.9996	7/6/2058 0:00	12605	20.7484	8/21/2058 0:00	12651	20.5051
4/6/2058 0:00	12514	21.2532	5/22/2058 0:00	12560	20.994	7/7/2058 0:00	12606	20.7431	8/22/2058 0:00	12652	20.4999
4/7/2058 0:00	12515	21.2475	5/23/2058 0:00	12561	20.9885	7/8/2058 0:00	12607	20.7377	8/23/2058 0:00	12653	20.4947
4/8/2058 0:00	12516	21.2417	5/24/2058 0:00	12562	20.9829	7/9/2058 0:00	12608	20.7323	8/24/2058 0:00	12654	20.4895
4/9/2058 0:00	12517	21.236	5/25/2058 0:00	12563	20.9774	7/10/2058 0:00	12609	20.727	8/25/2058 0:00	12655	20.4843
4/10/2058 0:00	12518	21.2303	5/26/2058 0:00	12564	20.9719	7/11/2058 0:00	12610	20.7216	8/26/2058 0:00	12656	20.4791
4/11/2058 0:00	12519	21.2246	5/27/2058 0:00	12565	20.9663	7/12/2058 0:00	12611	20.7163	8/27/2058 0:00	12657	20.4739
4/12/2058 0:00	12520	21.2189	5/28/2058 0:00	12566	20.9608	7/13/2058 0:00	12612	20.7109	8/28/2058 0:00	12658	20.4688
4/13/2058 0:00	12521	21.2132	5/29/2058 0:00	12567	20.9553	7/14/2058 0:00	12613	20.7056	8/29/2058 0:00	12659	20.4636
4/14/2058 0:00	12522	21.2075	5/30/2058 0:00	12568	20.9498	7/15/2058 0:00	12614	20.7002	8/30/2058 0:00	12660	20.4584
4/15/2058 0:00	12523	21.2018	5/31/2058 0:00	12569	20.9443	7/16/2058 0:00	12615	20.6949	8/31/2058 0:00	12661	20.4532
4/16/2058 0:00	12524	21.1961	6/1/2058 0:00	12570	20.9388	7/17/2058 0:00	12616	20.6896	9/1/2058 0:00	12662	20.4481
4/17/2058 0:00	12525	21.1904	6/2/2058 0:00	12571	20.9333	7/18/2058 0:00	12617	20.6842	9/2/2058 0:00	12663	20.4429
4/18/2058 0:00	12526	21.1848	6/3/2058 0:00	12572	20.9278	7/19/2058 0:00	12618	20.6789	9/3/2058 0:00	12664	20.4377
4/19/2058 0:00	12527	21.1791	6/4/2058 0:00	12573	20.9223	7/20/2058 0:00	12619	20.6736	9/4/2058 0:00	12665	20.4326
4/20/2058 0:00	12528	21.1734	6/5/2058 0:00	12574	20.9168	7/21/2058 0:00	12620	20.6683	9/5/2058 0:00	12666	20.4274
4/21/2058 0:00	12529	21.1677	6/6/2058 0:00	12575	20.9113	7/22/2058 0:00	12621	20.663	9/6/2058 0:00	12667	20.4222
4/22/2058 0:00	12530	21.1621	6/7/2058 0:00	12576	20.9058	7/23/2058 0:00	12622	20.6576	9/7/2058 0:00	12668	20.4171
4/23/2058 0:00	12531	21.1564	6/8/2058 0:00	12577	20.9003	7/24/2058 0:00	12623	20.6523	9/8/2058 0:00	12669	20.4119
4/24/2058 0:00	12532	21.1508	6/9/2058 0:00	12578	20.8949	7/25/2058 0:00	12624	20.647	9/9/2058 0:00	12670	20.4068
4/25/2058 0:00	12533	21.1451	6/10/2058 0:00	12579	20.8894	7/26/2058 0:00	12625	20.6417	9/10/2058 0:00	12671	20.4017
4/26/2058 0:00	12534	21.1395	6/11/2058 0:00	12580	20.8839	7/27/2058 0:00	12626	20.6364	9/11/2058 0:00	12672	20.3965
4/27/2058 0:00	12535	21.1338	6/12/2058 0:00	12581	20.8785	7/28/2058 0:00	12627	20.6311	9/12/2058 0:00	12673	20.3914
4/28/2058 0:00	12536	21.1282	6/13/2058 0:00	12582	20.873	7/29/2058 0:00	12628	20.6258	9/13/2058 0:00	12674	20.3863
4/29/2058 0:00	12537	21.1225	6/14/2058 0:00	12583	20.8675	7/30/2058 0:00	12629	20.6206	9/14/2058 0:00	12675	20.3811
4/30/2058 0:00	12538	21.1169	6/15/2058 0:00	12584	20.8621	7/31/2058 0:00	12630	20.6153	9/15/2058 0:00	12676	20.376
5/1/2058 0:00	12539	21.1113	6/16/2058 0:00	12585	20.8566	8/1/2058 0:00	12631	20.61	9/16/2058 0:00	12677	20.3709
5/2/2058 0:00	12540	21.1057	6/17/2058 0:00	12586	20.8512	8/2/2058 0:00	12632	20.6047	9/17/2058 0:00	12678	20.3658
5/3/2058 0:00	12541	21.1	6/18/2058 0:00	12587	20.8458	8/3/2058 0:00	12633	20.5994	9/18/2058 0:00	12679	20.3607
5/4/2058 0:00	12542	21.0944	6/19/2058 0:00	12588	20.8403	8/4/2058 0:00	12634	20.5942	9/19/2058 0:00	12680	20.3555
5/5/2058 0:00	12543	21.0888	6/20/2058 0:00	12589	20.8349	8/5/2058 0:00	12635	20.5889	9/20/2058 0:00	12681	20.3504
5/6/2058 0:00	12544	21.0832	6/21/2058 0:00	12590	20.8295	8/6/2058 0:00	12636	20.5836	9/21/2058 0:00	12682	20.3453
5/7/2058 0:00	12545	21.0776	6/22/2058 0:00	12591	20.824	8/7/2058 0:00	12637	20.5784	9/22/2058 0:00	12683	20.3402

9/23/2058 0:00	12684	20.3351	11/8/2058 0:00	12730	20.1042	12/24/2058 0:00	12776	19.88	2/8/2059 0:00	12822	19.6622
9/24/2058 0:00	12685	20.33	11/9/2058 0:00	12731	20.0993	12/25/2058 0:00	12777	19.8752	2/9/2059 0:00	12823	19.6576
9/25/2058 0:00	12686	20.325	11/10/2058 0:00	12732	20.0943	12/26/2058 0:00	12778	19.8704	2/10/2059 0:00	12824	19.6529
9/26/2058 0:00	12687	20.3199	11/11/2058 0:00	12733	20.0894	12/27/2058 0:00	12779	19.8656	2/11/2059 0:00	12825	19.6482
9/27/2058 0:00	12688	20.3148	11/12/2058 0:00	12734	20.0845	12/28/2058 0:00	12780	19.8609	2/12/2059 0:00	12826	19.6436
9/28/2058 0:00	12689	20.3097	11/13/2058 0:00	12735	20.0795	12/29/2058 0:00	12781	19.8561	2/13/2059 0:00	12827	19.6389
9/29/2058 0:00	12690	20.3046	11/14/2058 0:00	12736	20.0746	12/30/2058 0:00	12782	19.8513	2/14/2059 0:00	12828	19.6343
9/30/2058 0:00	12691	20.2996	11/15/2058 0:00	12737	20.0697	12/31/2058 0:00	12783	19.8465	2/15/2059 0:00	12829	19.6296
10/1/2058 0:00	12692	20.2945	11/16/2058 0:00	12738	20.0648	1/1/2059 0:00	12784	19.8417	2/16/2059 0:00	12830	19.625
10/2/2058 0:00	12693	20.2894	11/17/2058 0:00	12739	20.0599	1/2/2059 0:00	12785	19.8369	2/17/2059 0:00	12831	19.6203
10/3/2058 0:00	12694	20.2844	11/18/2058 0:00	12740	20.0549	1/3/2059 0:00	12786	19.8322	2/18/2059 0:00	12832	19.6157
10/4/2058 0:00	12695	20.2793	11/19/2058 0:00	12741	20.05	1/4/2059 0:00	12787	19.8274	2/19/2059 0:00	12833	19.6111
10/5/2058 0:00	12696	20.2742	11/20/2058 0:00	12742	20.0451	1/5/2059 0:00	12788	19.8226	2/20/2059 0:00	12834	19.6064
10/6/2058 0:00	12697	20.2692	11/21/2058 0:00	12743	20.0402	1/6/2059 0:00	12789	19.8179	2/21/2059 0:00	12835	19.6018
10/7/2058 0:00	12698	20.2641	11/22/2058 0:00	12744	20.0353	1/7/2059 0:00	12790	19.8131	2/22/2059 0:00	12836	19.5972
10/8/2058 0:00	12699	20.2591	11/23/2058 0:00	12745	20.0304	1/8/2059 0:00	12791	19.8083	2/23/2059 0:00	12837	19.5925
10/9/2058 0:00	12700	20.254	11/24/2058 0:00	12746	20.0255	1/9/2059 0:00	12792	19.8036	2/24/2059 0:00	12838	19.5879
10/10/2058 0:00	12701	20.249	11/25/2058 0:00	12747	20.0206	1/10/2059 0:00	12793	19.7988	2/25/2059 0:00	12839	19.5833
10/11/2058 0:00	12702	20.244	11/26/2058 0:00	12748	20.0157	1/11/2059 0:00	12794	19.7941	2/26/2059 0:00	12840	19.5787
10/12/2058 0:00	12703	20.2389	11/27/2058 0:00	12749	20.0108	1/12/2059 0:00	12795	19.7893	2/27/2059 0:00	12841	19.5741
10/13/2058 0:00	12704	20.2339	11/28/2058 0:00	12750	20.006	1/13/2059 0:00	12796	19.7846	2/28/2059 0:00	12842	19.5694
10/14/2058 0:00	12705	20.2289	11/29/2058 0:00	12751	20.0011	1/14/2059 0:00	12797	19.7798	3/1/2059 0:00	12843	19.5648
10/15/2058 0:00	12706	20.2238	11/30/2058 0:00	12752	19.9962	1/15/2059 0:00	12798	19.7751	3/2/2059 0:00	12844	19.5602
10/16/2058 0:00	12707	20.2188	12/1/2058 0:00	12753	19.9913	1/16/2059 0:00	12799	19.7704	3/3/2059 0:00	12845	19.5556
10/17/2058 0:00	12708	20.2138	12/2/2058 0:00	12754	19.9864	1/17/2059 0:00	12800	19.7656	3/4/2059 0:00	12846	19.551
10/18/2058 0:00	12709	20.2088	12/3/2058 0:00	12755	19.9816	1/18/2059 0:00	12801	19.7609	3/5/2059 0:00	12847	19.5464
10/19/2058 0:00	12710	20.2038	12/4/2058 0:00	12756	19.9767	1/19/2059 0:00	12802	19.7562	3/6/2059 0:00	12848	19.5418
10/20/2058 0:00	12711	20.1988	12/5/2058 0:00	12757	19.9719	1/20/2059 0:00	12803	19.7514	3/7/2059 0:00	12849	19.5372
10/21/2058 0:00	12712	20.1938	12/6/2058 0:00	12758	19.967	1/21/2059 0:00	12804	19.7467	3/8/2059 0:00	12850	19.5326
10/22/2058 0:00	12713	20.1888	12/7/2058 0:00	12759	19.9621	1/22/2059 0:00	12805	19.742	3/9/2059 0:00	12851	19.528
10/23/2058 0:00	12714	20.1838	12/8/2058 0:00	12760	19.9573	1/23/2059 0:00	12806	19.7373	3/10/2059 0:00	12852	19.5235
10/24/2058 0:00	12715	20.1788	12/9/2058 0:00	12761	19.9524	1/24/2059 0:00	12807	19.7326	3/11/2059 0:00	12853	19.5189
10/25/2058 0:00	12716	20.1738	12/10/2058 0:00	12762	19.9476	1/25/2059 0:00	12808	19.7279	3/12/2059 0:00	12854	19.5143
10/26/2058 0:00	12717	20.1688	12/11/2058 0:00	12763	19.9427	1/26/2059 0:00	12809	19.7232	3/13/2059 0:00	12855	19.5097
10/27/2058 0:00	12718	20.1638	12/12/2058 0:00	12764	19.9379	1/27/2059 0:00	12810	19.7185	3/14/2059 0:00	12856	19.5052
10/28/2058 0:00	12719	20.1588	12/13/2058 0:00	12765	19.9331	1/28/2059 0:00	12811	19.7138	3/15/2059 0:00	12857	19.5006
10/29/2058 0:00	12720	20.1538	12/14/2058 0:00	12766	19.9282	1/29/2059 0:00	12812	19.7091	3/16/2059 0:00	12858	19.496
10/30/2058 0:00	12721	20.1489	12/15/2058 0:00	12767	19.9234	1/30/2059 0:00	12813	19.7044	3/17/2059 0:00	12859	19.4914
10/31/2058 0:00	12722	20.1439	12/16/2058 0:00	12768	19.9186	1/31/2059 0:00	12814	19.6997	3/18/2059 0:00	12860	19.4869
11/1/2058 0:00	12723	20.1389	12/17/2058 0:00	12769	19.9137	2/1/2059 0:00	12815	19.695	3/19/2059 0:00	12861	19.4823
11/2/2058 0:00	12724	20.134	12/18/2058 0:00	12770	19.9089	2/2/2059 0:00	12816	19.6903	3/20/2059 0:00	12862	19.4778
11/3/2058 0:00	12725	20.129	12/19/2058 0:00	12771	19.9041	2/3/2059 0:00	12817	19.6856	3/21/2059 0:00	12863	19.4732
11/4/2058 0:00	12726	20.124	12/20/2058 0:00	12772	19.8993	2/4/2059 0:00	12818	19.6809	3/22/2059 0:00	12864	19.4687
11/5/2058 0:00	12727	20.1191	12/21/2058 0:00	12773	19.8945	2/5/2059 0:00	12819	19.6762	3/23/2059 0:00	12865	19.4641
11/6/2058 0:00	12728	20.1141	12/22/2058 0:00	12774	19.8897	2/6/2059 0:00	12820	19.6716	3/24/2059 0:00	12866	19.4596
11/7/2058 0:00	12729	20.1092	12/23/2058 0:00	12775	19.8848	2/7/2059 0:00	12821	19.6669	3/25/2059 0:00	12867	19.455

3/26/2059 0:00	12868	19.4505	5/11/2059 0:00	12914	19.2445	6/26/2059 0:00	12960	19.044	8/11/2059 0:00	13006	18.8488
3/27/2059 0:00	12869	19.4459	5/12/2059 0:00	12915	19.2401	6/27/2059 0:00	12961	19.0397	8/12/2059 0:00	13007	18.8446
3/28/2059 0:00	12870	19.4414	5/13/2059 0:00	12916	19.2357	6/28/2059 0:00	12962	19.0354	8/13/2059 0:00	13008	18.8404
3/29/2059 0:00	12871	19.4369	5/14/2059 0:00	12917	19.2313	6/29/2059 0:00	12963	19.0311	8/14/2059 0:00	13009	18.8362
3/30/2059 0:00	12872	19.4323	5/15/2059 0:00	12918	19.2268	6/30/2059 0:00	12964	19.0268	8/15/2059 0:00	13010	18.832
3/31/2059 0:00	12873	19.4278	5/16/2059 0:00	12919	19.2224	7/1/2059 0:00	12965	19.0225	8/16/2059 0:00	13011	18.8278
4/1/2059 0:00	12874	19.4233	5/17/2059 0:00	12920	19.218	7/2/2059 0:00	12966	19.0182	8/17/2059 0:00	13012	18.8237
4/2/2059 0:00	12875	19.4188	5/18/2059 0:00	12921	19.2136	7/3/2059 0:00	12967	19.014	8/18/2059 0:00	13013	18.8195
4/3/2059 0:00	12876	19.4143	5/19/2059 0:00	12922	19.2092	7/4/2059 0:00	12968	19.0097	8/19/2059 0:00	13014	18.8153
4/4/2059 0:00	12877	19.4097	5/20/2059 0:00	12923	19.2048	7/5/2059 0:00	12969	19.0054	8/20/2059 0:00	13015	18.8111
4/5/2059 0:00	12878	19.4052	5/21/2059 0:00	12924	19.2005	7/6/2059 0:00	12970	19.0011	8/21/2059 0:00	13016	18.807
4/6/2059 0:00	12879	19.4007	5/22/2059 0:00	12925	19.1961	7/7/2059 0:00	12971	18.9968	8/22/2059 0:00	13017	18.8028
4/7/2059 0:00	12880	19.3962	5/23/2059 0:00	12926	19.1917	7/8/2059 0:00	12972	18.9926	8/23/2059 0:00	13018	18.7987
4/8/2059 0:00	12881	19.3917	5/24/2059 0:00	12927	19.1873	7/9/2059 0:00	12973	18.9883	8/24/2059 0:00	13019	18.7945
4/9/2059 0:00	12882	19.3872	5/25/2059 0:00	12928	19.1829	7/10/2059 0:00	12974	18.984	8/25/2059 0:00	13020	18.7903
4/10/2059 0:00	12883	19.3827	5/26/2059 0:00	12929	19.1785	7/11/2059 0:00	12975	18.9798	8/26/2059 0:00	13021	18.7862
4/11/2059 0:00	12884	19.3782	5/27/2059 0:00	12930	19.1742	7/12/2059 0:00	12976	18.9755	8/27/2059 0:00	13022	18.782
4/12/2059 0:00	12885	19.3737	5/28/2059 0:00	12931	19.1698	7/13/2059 0:00	12977	18.9713	8/28/2059 0:00	13023	18.7779
4/13/2059 0:00	12886	19.3692	5/29/2059 0:00	12932	19.1654	7/14/2059 0:00	12978	18.967	8/29/2059 0:00	13024	18.7737
4/14/2059 0:00	12887	19.3647	5/30/2059 0:00	12933	19.161	7/15/2059 0:00	12979	18.9627	8/30/2059 0:00	13025	18.7696
4/15/2059 0:00	12888	19.3602	5/31/2059 0:00	12934	19.1567	7/16/2059 0:00	12980	18.9585	8/31/2059 0:00	13026	18.7654
4/16/2059 0:00	12889	19.3557	6/1/2059 0:00	12935	19.1523	7/17/2059 0:00	12981	18.9542	9/1/2059 0:00	13027	18.7613
4/17/2059 0:00	12890	19.3513	6/2/2059 0:00	12936	19.1479	7/18/2059 0:00	12982	18.95	9/2/2059 0:00	13028	18.7572
4/18/2059 0:00	12891	19.3468	6/3/2059 0:00	12937	19.1436	7/19/2059 0:00	12983	18.9457	9/3/2059 0:00	13029	18.753
4/19/2059 0:00	12892	19.3423	6/4/2059 0:00	12938	19.1392	7/20/2059 0:00	12984	18.9415	9/4/2059 0:00	13030	18.7489
4/20/2059 0:00	12893	19.3378	6/5/2059 0:00	12939	19.1349	7/21/2059 0:00	12985	18.9373	9/5/2059 0:00	13031	18.7448
4/21/2059 0:00	12894	19.3334	6/6/2059 0:00	12940	19.1305	7/22/2059 0:00	12986	18.933	9/6/2059 0:00	13032	18.7406
4/22/2059 0:00	12895	19.3289	6/7/2059 0:00	12941	19.1262	7/23/2059 0:00	12987	18.9288	9/7/2059 0:00	13033	18.7365
4/23/2059 0:00	12896	19.3244	6/8/2059 0:00	12942	19.1218	7/24/2059 0:00	12988	18.9246	9/8/2059 0:00	13034	18.7324
4/24/2059 0:00	12897	19.32	6/9/2059 0:00	12943	19.1175	7/25/2059 0:00	12989	18.9203	9/9/2059 0:00	13035	18.7283
4/25/2059 0:00	12898	19.3155	6/10/2059 0:00	12944	19.1131	7/26/2059 0:00	12990	18.9161	9/10/2059 0:00	13036	18.7241
4/26/2059 0:00	12899	19.311	6/11/2059 0:00	12945	19.1088	7/27/2059 0:00	12991	18.9119	9/11/2059 0:00	13037	18.72
4/27/2059 0:00	12900	19.3066	6/12/2059 0:00	12946	19.1045	7/28/2059 0:00	12992	18.9076	9/12/2059 0:00	13038	18.7159
4/28/2059 0:00	12901	19.3021	6/13/2059 0:00	12947	19.1001	7/29/2059 0:00	12993	18.9034	9/13/2059 0:00	13039	18.7118
4/29/2059 0:00	12902	19.2977	6/14/2059 0:00	12948	19.0958	7/30/2059 0:00	12994	18.8992	9/14/2059 0:00	13040	18.7077
4/30/2059 0:00	12903	19.2932	6/15/2059 0:00	12949	19.0915	7/31/2059 0:00	12995	18.895	9/15/2059 0:00	13041	18.7036
5/1/2059 0:00	12904	19.2888	6/16/2059 0:00	12950	19.0871	8/1/2059 0:00	12996	18.8908	9/16/2059 0:00	13042	18.6995
5/2/2059 0:00	12905	19.2844	6/17/2059 0:00	12951	19.0828	8/2/2059 0:00	12997	18.8866	9/17/2059 0:00	13043	18.6953
5/3/2059 0:00	12906	19.2799	6/18/2059 0:00	12952	19.0785	8/3/2059 0:00	12998	18.8823	9/18/2059 0:00	13044	18.6912
5/4/2059 0:00	12907	19.2755	6/19/2059 0:00	12953	19.0742	8/4/2059 0:00	12999	18.8781	9/19/2059 0:00	13045	18.6871
5/5/2059 0:00	12908	19.271	6/20/2059 0:00	12954	19.0699	8/5/2059 0:00	13000	18.8739	9/20/2059 0:00	13046	18.683
5/6/2059 0:00	12909	19.2666	6/21/2059 0:00	12955	19.0655	8/6/2059 0:00	13001	18.8697	9/21/2059 0:00	13047	18.679
5/7/2059 0:00	12910	19.2622	6/22/2059 0:00	12956	19.0612	8/7/2059 0:00	13002	18.8655	9/22/2059 0:00	13048	18.6749
5/8/2059 0:00	12911	19.2578	6/23/2059 0:00	12957	19.0569	8/8/2059 0:00	13003	18.8613	9/23/2059 0:00	13049	18.6708
5/9/2059 0:00	12912	19.2533	6/24/2059 0:00	12958	19.0526	8/9/2059 0:00	13004	18.8571	9/24/2059 0:00	13050	18.6667
5/10/2059 0:00	12913	19.2489	6/25/2059 0:00	12959	19.0483	8/10/2059 0:00	13005	18.8529	9/25/2059 0:00	13051	18.6626

9/26/2059 0:00	13052	18.6585
9/27/2059 0:00	13053	18.6544
9/28/2059 0:00	13054	18.6503
9/29/2059 0:00	13055	18.6463
9/30/2059 0:00	13056	18.6422
10/1/2059 0:00	13057	18.6381
10/2/2059 0:00	13058	18.6341
10/3/2059 0:00	13059	18.63
10/4/2059 0:00	13060	18.6259
10/5/2059 0:00	13061	18.6219
10/6/2059 0:00	13062	18.6178
10/7/2059 0:00	13063	18.6137
10/8/2059 0:00	13064	18.6097
10/9/2059 0:00	13065	18.6056
10/10/2059 0:00	13066	18.6016
10/11/2059 0:00	13067	18.5975
10/12/2059 0:00	13068	18.5935
10/13/2059 0:00	13069	18.5894
10/14/2059 0:00	13070	18.5854
10/15/2059 0:00	13071	18.5813
10/16/2059 0:00	13072	18.5773
10/17/2059 0:00	13073	18.5733
10/18/2059 0:00	13074	18.5692
10/19/2059 0:00	13075	18.5652
10/20/2059 0:00	13076	18.5612
10/21/2059 0:00	13077	18.5571
10/22/2059 0:00	13078	18.5531
10/23/2059 0:00	13079	18.5491
10/24/2059 0:00	13080	18.5451
10/25/2059 0:00	13081	18.541
10/26/2059 0:00	13082	18.537
10/27/2059 0:00	13083	18.533
10/28/2059 0:00	13084	18.529
10/29/2059 0:00	13085	18.525
10/30/2059 0:00	13086	18.521
10/31/2059 0:00	13087	18.517
11/1/2059 0:00	13088	18.513
11/2/2059 0:00	13089	18.509
11/3/2059 0:00	13090	18.505
11/4/2059 0:00	13091	18.501
11/5/2059 0:00	13092	18.497
11/6/2059 0:00	13093	18.493
11/7/2059 0:00	13094	18.489
11/8/2059 0:00	13095	18.485
11/9/2059 0:00	13096	18.481
11/10/2059 0:00	13097	18.477
11/11/2059 0:00	13098	18.473
11/12/2059 0:00	13099	18.4691
11/13/2059 0:00	13100	18.4651
11/14/2059 0:00	13101	18.4611
11/15/2059 0:00	13102	18.4571
11/16/2059 0:00	13103	18.4532
11/17/2059 0:00	13104	18.4492
11/18/2059 0:00	13105	18.4452
11/19/2059 0:00	13106	18.4413
11/20/2059 0:00	13107	18.4373
11/21/2059 0:00	13108	18.4333
11/22/2059 0:00	13109	18.4294
11/23/2059 0:00	13110	18.4254
11/24/2059 0:00	13111	18.4215
11/25/2059 0:00	13112	18.4175
11/26/2059 0:00	13113	18.4136
11/27/2059 0:00	13114	18.4096
11/28/2059 0:00	13115	18.4057
11/29/2059 0:00	13116	18.4017
11/30/2059 0:00	13117	18.3978
12/1/2059 0:00	13118	18.3938
12/2/2059 0:00	13119	18.3899
12/3/2059 0:00	13120	18.386
12/4/2059 0:00	13121	18.382
12/5/2059 0:00	13122	18.3781
12/6/2059 0:00	13123	18.3742
12/7/2059 0:00	13124	18.3703
12/8/2059 0:00	13125	18.3663
12/9/2059 0:00	13126	18.3624
12/10/2059 0:00	13127	18.3585
12/11/2059 0:00	13128	18.3546
12/12/2059 0:00	13129	18.3507
12/13/2059 0:00	13130	18.3467
12/14/2059 0:00	13131	18.3428
12/15/2059 0:00	13132	18.3389
12/16/2059 0:00	13133	18.335
12/17/2059 0:00	13134	18.3311
12/18/2059 0:00	13135	18.3272
12/19/2059 0:00	13136	18.3233
12/20/2059 0:00	13137	18.3194
12/21/2059 0:00	13138	18.3155
12/22/2059 0:00	13139	18.3116
12/23/2059 0:00	13140	18.3077
12/24/2059 0:00	13141	18.3038
12/25/2059 0:00	13142	18.2999
12/26/2059 0:00	13143	18.296
12/27/2059 0:00	13144	18.2922
12/28/2059 0:00	13145	18.2883
12/29/2059 0:00	13146	18.2844
12/30/2059 0:00	13147	18.2805
12/31/2059 0:00	13148	18.2766
1/1/2060 0:00	13149	18.2728

SECTION VIII

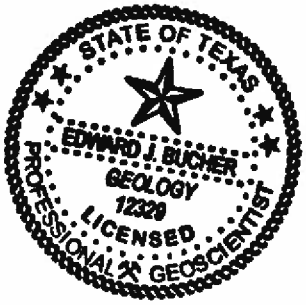
AREA OF REVIEW REPORT

GEOSCIENTIST'S SEAL

I, Edward J. Bucher, P.G., the undersigned, state: I am employed by WSP USA, and I am authorized to prepare this document. This document was prepared under my supervision and direction. The information in this document was prepared in accordance with generally accepted geosciences principles and practices.

This certification and seal apply to the following documents:

Pages VIII-1 through VIII-5
Tables VIII-1 through VIII-2
Appendix VIII-1 Records and Schematics of Non-Freshwater Artificial Penetrations within 2.5 Mile Area of Review



Name: Edward J. Bucher, P.G.
Title: Senior Geologist
WSP USA Inc.
Texas Geoscience Firm 50561

Signature Edward J. Bucher Date Signed 12/27/2023
Licensed Professional Geologist No. 12329

VIII. AREA OF REVIEW

A base map showing the location, name, number, and depth of the artificial penetrations in the AOR is included as Attachment D-3. This map shows the location of the proposed Class I injection well and of non-freshwater penetrations, including existing and plugged and abandoned injection wells and all oil and gas wells. Based on the results of the modeling in Section VII.A.7, the AOR is greater than the cone of influence (COI). As a result, the 2.5-mile radius AOR will be used in this section.

VIII.A MAPS OF WATER WELLS AND NON-FRESHWATER ARTIFICIAL PENETRATIONS

A topographic map depicting the water wells located within 2.5 miles of the NTI Facility is provided as Attachment D-2.

VIII.B PROTOCOL FOR IDENTIFYING NON-FRESHWATER ARTIFICIAL PENETRATIONS

(a) SEARCH PROTOCOL FOR NON-FRESHWATER ARTIFICIAL PENETRATIONS

D-B Associates was subcontracted to search public and private sources of data to identify oil, gas, and Class II injection wells located in an AOR. D-B Associates understands the necessity for complete records and makes every diligent effort to complete this task.

The RRC is the primary agency in which files are researched for oil and gas well records. The RRC is the state repository for oil and gas well and Class II well records, as the state regulatory authority for the oil and gas industry. In order to retrieve well records, the following general, outlined procedure is used for researching each well within a given area:

(b) MAP REVIEW

Before the retrieval process can begin, it is necessary to know the operator, lease name, county in which the well is located, and the name of the survey in which the well is found. The preceding information is normally found on commercially prepared oil and gas base maps. The RRC maintains maps which are used by the researcher to determine operator, well name, approximate drilling date, and field name.

Some maps are produced by commercial firms, who obtained the data to build the oil and gas bases from "scout" tickets (completion information received from individual oil companies) in the early years and then, in later years, from the RRC itself. The RRC purchases these maps and utilizes them as base maps, plotting incoming information filed by oil and gas operators. Changes in the status of existing wells are notated, as well as factual material on new wells. When the RRC purchases the commercial base, the information found on the maps is accepted as correct and no attempt is made to verify the data unless a discrepancy is noted when a well's status is updated.

(c) MICROFILM RECORDS REVIEW

All records filed with the RRC prior to 1973 are found on microfiche and microfilm. Records in some RRC districts are filmed through 1980. These microfiche and microfilm records are organized in several different systems, such as operator and lease name; or district, field, and operator name; or district, field, and lease number.

(d) UNIT CARDS

These are microfiche records for wells which had records filed with the RRC prior to 1962. These "units" are filed sequentially by an operator number assigned by the RRC at the time the operator filed the required organization report with the agency. The operator number can be referenced in either the "county book" or the "county microfiche". There is a "county book" maintained for each county within the state. Within the "county book" the information is organized alphabetically by lease name, which cross references to the operator name and corresponding operator number. The "county microfiche" are a recent addition to the RRC filing system. Using the "county books", the agency reorganized the leases into alphabetic order and microfilmed the information. Although the "county books" are not organized as neatly as the "county microfiche", they are the original system and are more accurate due to unintentional omissions made when reorganizing the listings.

Operator numbers can also be obtained from old copies of organization ledgers maintained by the RRC. These ledgers are in five separate sets which correspond to various time periods from the 1920s to the 1960s. These ledgers list only operator names, addresses, and numbers assigned by the agency and are used as a last resort since they do not indicate lease names and often list multiple operators with the same name.

Once the operator name is matched to a lease name and an operator number is given, the unit card, if available, is pulled. The lease names are filed alphabetically within each operator number. Since there are exceptions to the filing system, if the desired information is not available, or only partially available on the unit card, then the researcher must proceed to the next set of microfilm.

(e) WELL RECORDS - FOLDER ROLLS

Duplicate copies of unit cards, which sometimes contain information that was not included in the initial filming of the unit cards, are referenced on the folder rolls. The folder rolls are organized by operator number and folder number which appear on the unit card jacket. In addition, some folder rolls do not have a folder number given, but only an operator number. These rolls are called "add-on rolls" and contain records not included in the initial filming of the unit cards.

(f) WELL RECORDS - MAJOR RUNS

This is a special set of film that contains only information on records filed by major operators. These rolls are organized by operator and then alphabetically by lease name. It should be noted that there are very few unit cards for major companies and that if any information was filed on a lease or well, it will be found on this set of film. It should also be noted that major operators, even in the early years of the oil business, were very prudent about filing completions and plugs for wells which they operated.

(g) WELL RECORDS - K, L, AND M FILM

In March 1966, the RRC instituted a new filing system; however, before the system could be fully implemented, many well records which were filed during the period of transition were placed onto the K, L, and M film. The K

Run covers portions of records filed from 1963 to 1964; the L Run covers portions of records filed from 1964 to 1965; and the M Run covers portions of records filed from 1965 to March 1966. The K, L, and M film sets are organized by operator number, with leases listed alphabetically within each operator number.

(h) POTENTIAL FILM

In March 1966, the RRC filing system was converted to the "potential" filing system, which is currently used today. This film contains records of all wells that produced oil and/or gas and were placed in a designated oil or gas field. This film is organized by the RRC district, field name, and oil lease number or gas well identification number.

(i) WILDCAT AND SUSPENSE FILM

The wells on this set of film differ in that they were to be drilled in wildcat fields or fields which were not producing at the time the Application to Drill was submitted to the RRC. This film is organized by district, county, and/or API number. The API numbering system has been in effect since April 1966. The numbers have been stored within the RRC 's computer system, as well as being noted on all forms filed for the well. The system allows information to be retrieved by computer showing drilling status, operator, lease name, oil lease number or gas identification number, and field name. This is a very efficient system and allows quick and accurate retrieval of data filed since 1978.

(j) WELL RECORD FILES

These are the hard copy files of data not yet placed on microfilm. These files are organized by district, field name, and oil lease number or gas identification number. These files contain the most recent data processed by the Central Records staff of the RRC. Inside these folders are references to data that have been placed onto potential film.

(k) SUSPENSE FILES

These files contain the most recent information to be filed with the RRC, Central Records Department. This is the holding area for information to be placed into existing well record files or to have new oil lease or gas identification files prepared. The information is filed by district and API number. To obtain API numbers assigned to these records, it is necessary to search "suspense cards" that are filed by district, county, and alphabetically by lease name. Records that have not been placed in suspense files are usually found within the RRC, Map Department, where they are held until data are placed on the county oil and gas base maps or on field maps.

(l) SUMMARY

The RRC filing system is the best source of oil and gas well data in Texas. This agency can usually provide 95-100% of the data needed. In particular areas of the state, drilling activity was especially heavy and instituted very early in this century. In some of these areas, information has slipped through the system of the RRC. In the cases where this has occurred, the other sources previously mentioned can usually complete these record gaps.

(m) SEARCH PROTOCOL FOR SHALLOW WATER WELLS

D-B Associates utilized public sources of data to identify water wells located within 2.5 miles of the facility. D-B Associates reviewed ground water resource reports for Hill County, prepared by the USGS in cooperation with the Texas Board of Water Engineers (TBWE), the Texas Department of Water Resources (TDWR), and Texas Water Development Board (TWDB). D-B Associates examined located well and plotted well files and unfiled water well reports for Hill County at the TWDB office. They also examined Hill County unfiled water well reports at the TCEQ Central Records.

VIII.C ARTIFICIAL PENETRATION TABULATIONS AND WELL RECORDS

A tabulation of data on all recorded non-freshwater artificial penetrations within 2.5 miles of the NTI Facility is provided as Table VIII-1. Well records available from the RRC are provided in Appendix VIII-1. Wells in Table VIII-1 are identified with map identification numbers (Map ID Nos.) (the terms Map ID No. and Map ID Nos. are used interchangeably in this document) keyed to Attachment D-3 and Appendix VIII-1.

Water wells are listed in Table VIII-2. Water wells in Table VIII-2 are identified with Map ID Nos. keyed to Attachment D-2.

VIII.D WELL SCHEMATICS

Schematics of the non-freshwater artificial penetrations within the AOR are included in Appendix VIII-1. A base map with the COI is shown on Attachment D-3.

VIII.E CONDITION OF NON-FRESHWATER ARTIFICIAL PENETRATIONS WITHIN THE CONE OF INFLUENCE

Each well was evaluated to determine if it will allow movement of fluids into or between USDWs. For the purpose of this demonstration, the 2 artificial penetrations found within the 2.5-mile AOR from the NTI Facility are discussed individually.

(a) ENDEAVOR ENERGY RESOURCES LP WELL 1H

This directional well (API 42-271-30529) is owned and operated by Endeavor Energy Resources LP. Drilling commenced on December 23, 2007, supposedly into the Ellenberger Formation, reaching approximately 12,037 ft measured depth. The well completion record on file with RRC and TCEQ indicate this well was sidetracked twice: (1) from 8,600 – 9,501 ft and (2) from 8,600 – 11,972 ft Additionally, the well looks to be plugged back to 9,235 ft and there are 8-3/4" cement plugs set at 8,532 ft with 350 sacks and at 8,366 ft with 640 sacks. These plugs sufficiently isolate the proposed Injection Zone from the USDW or any potential path. The 5-1/2" casing set into the proposed Ellenberger Formation Injection Zone is cemented outside the casing to approximately 3,968 ft, providing cemented casing throughout the proposed injection and Confining Zones.

(b) BECKNER M C WELL 1

This well (API 42-271-00019) is owned and operated by Beckner M C, reaching a total depth of approximately 1,006 ft. The well was drilled in 1951 and was dry and abandoned. The well does not penetrate the Injection or Confining Zone and poses no threat as a potential pathway or fluid migration.

VIII.F CORRECTIVE ACTION PLAN

No corrective action is required for non-freshwater artificial penetrations within the AOR.

VIII.G MONITORING PLAN

No monitoring plan in accordance with the requirements of §331.64(f)&(h)(1) [30 TAC §331.121(a)(2)(M)] is needed for this permit application.

TABLES

TABLE **VIII-1**

NON-FRESHWATER ARTIFICIAL PENETRATIONS WITH THE 2.5 MILE AREA OF REVIEW

AP No.	OPERATOR LEASE, WELL # SURVEY AND API NO.	Total Depth	STATUS PLUG DATE	TYPE	SIZE	DEPTH	CASING PULLED	TOP CMT	VOL CMT	INTERVAL (FEET)	CMT VOL	MUD FILLED? MUD WEIGHT? OPEN HOLE?
1	CM Beckner W J Norries Est No. 1 William O Merriwether A-562 API No. 42-217-000190000	1006	D&A 9/24/1951	No Records	No Records	No Records	No Records	No Records	No Records	No Records	No Records	No Records
2	Endeavor Energy Resourcs LP Presby No. 1H Matthew Jonett A-472 API No. 42-217-30529	12037 MD 9235 TVD	TA 3/27/2008	No Records	9.625 7.625 5.5/4.5	2224 9508 12037	No Records	Surf 5800 3968	1030 403 661	8366 - 9584	607	16 Y

TABLE VIII-2

WATER WELL TABULATION

Map ID No.	State Well No.	Owner	Water Use	Well Depth	Water Quality	Latitude	Longitude
1	126498	Reed, Ed	Domestic	99	no	32.221944	-97.112778
2	167330	B & B Water Well Services	Domestic	565	no	32.205278	-97.076389
3	277642	Stone Drilling	Domestic	578	no	32.157223	-97.106389
4	414089	charlie mitchell	Domestic	280	no	32.215804	-97.115037
5	416424	Clayton Sorrells	Domestic	320	no	32.212389	-97.102139
6	144724	Torino Retail S/S	Plugged Env. Soil Boring	21	no	32.169167	-97.1325
7	281401	EARTH TOUCH INC.	Plugged Env. Soil Boring	12		32.168055	-97.128889
8	281402	EARTH TOUCH INC.	Plugged Env. Soil Boring	8		32.168055	-97.128889
9	281403	EARTH TOUCH INC.	Plugged Env. Soil Boring	14		32.168055	-97.128889
10	281405	EARTH TOUCH INC.	Plugged Env. Soil Boring	4		32.168055	-97.128889
11	449078	Itasca Ventures, LLC	Environmental Soil Boring	10	no	32.168194	-97.134444
12	449080	Itasca Ventures, LLC	Environmental Soil Boring	5	no	32.168194	-97.134444
13	253920	Carroll Howard	Irrigation	300	no	32.201389	-97.118611
14	322312	DOUG WILLIAMS	Irrigation	320	no	32.179722	-97.139445
15	120430	Allied Waste	Monitor	17		32.184167	-97.108612
16	200961	Itasca Landfill TX, LP	Monitor	44.5		32.196945	-97.108056
17	201013	Itasca Landfill TX, LP	Monitor	35		32.1925	-97.113612
18	201016	Itasca Landfill TX, LP	Monitor	24.5		32.188056	-97.103334
19	201019	Itasca Landfill TX, LP	Monitor	25		32.197778	-97.106389
20	201020	Itasca Landfill TX, LP	Monitor	38.5		32.191389	-97.113889
21	201021	Itasca Landfill TX, LP	Monitor	34		32.189722	-97.114723
22	201023	Itasca Landfill TX, LP	Monitor	50		32.186667	-97.115556

TABLE VIII-2

WATER WELL TABULATION

Map ID No.	State Well No.	Owner	Water Use	Well Depth	Water Quality	Latitude	Longitude
23	201025	Itasca Landfill TX, LP	Monitor	52		32.185278	-97.115001
24	201026	Itasca Landfill TX, LP	Monitor	37.5		32.183889	-97.114167
25	201027	Itasca Landfill TX, LP	Monitor	38.5		32.199167	-97.113056
26	446179	Republic Services Inc.	Monitor	34	no	32.183742	-97.112378
27	84714	Itasca Landfill	Monitor			32.191389	-97.105834
28	84715	Itasca Landfill	Monitor			32.191389	-97.105834
29	84716	Itasca Landfill	Monitor			32.191389	-97.105834
30	84717	Itasca Landfill	Monitor			32.191389	-97.105834
31	370470	ITASCA LAND FILL	Monitor	38.5	no	32.1925	-97.113334
32	370471	ITASCA LAND FILL	Monitor	35	no	32.1925	-97.113334
33	370473	ITASCA LAND FILL	Monitor	25	no	32.1925	-97.113334
34	446181	Republic Services Inc.	Monitor	48	no	32.18419	-97.111911
35	446180	Republic Services Inc.	Monitor	48	no	32.184401	-97.111626
36	201029	Itasca Landfill TX, LP	Monitor	46		32.181111	-97.110278
37	95980	ITASCA LAND FILL	Monitor	38.5		32.1925	-97.113334
38	95981	ITASCA LAND FILL	Monitor	35		32.1925	-97.113334
39	95982	ITASCA LAND FILL	Monitor	25		32.1925	-97.113334
40	84718	Itasca Landfill	Monitor			32.191389	-97.105834
41	84720	Itasca Landfill	Monitor			32.191389	-97.105834
42	84721	Itasca Landfill	Monitor			32.191389	-97.105834
43	84722	Itasca Landfill	Monitor			32.191389	-97.105834
44	84723	Itasca Landfill	Monitor			32.191389	-97.105834

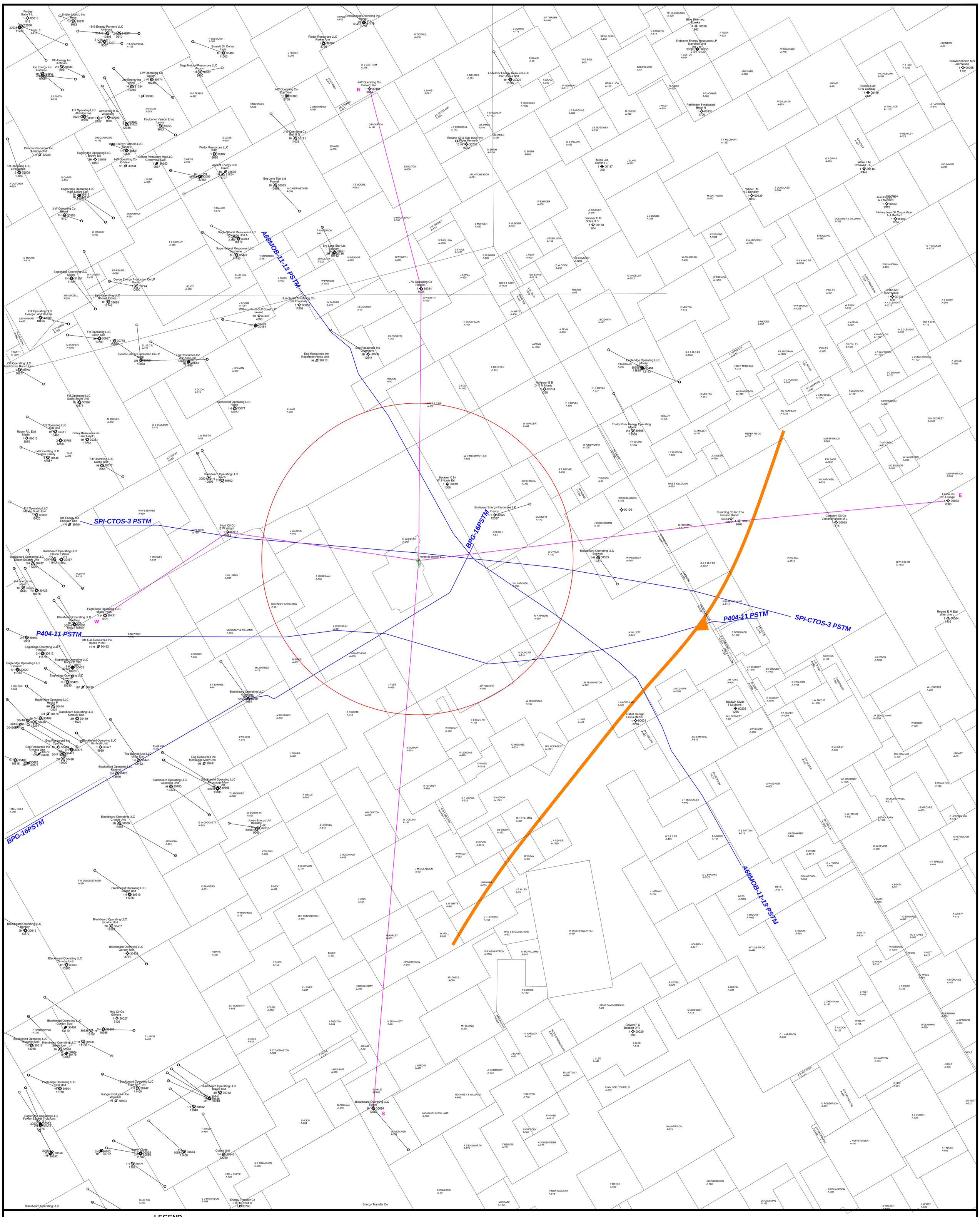
TABLE VIII-2

WATER WELL TABULATION

Map ID No.	State Well No.	Owner	Water Use	Well Depth	Water Quality	Latitude	Longitude
45	303857	Itasca Landfill	Monitor	24	no	32.191389	-97.105834
46	303858	Itasca Landfill	Monitor	34	no	32.191389	-97.105834
47	303860	Itasca Landfill	Monitor	21	no	32.191389	-97.105834
48	303862	Itasca Landfill	Monitor	25	no	32.191389	-97.105834
49	162890	Itasca Gardens Landfill	Monitor	19		32.194444	-97.108333
50	75741	Wagner & Brown	Rig Supply	430	no	32.219722	-97.116944
51	98656	Bob Strona dba Kings X Dairy	Stock	686	no	32.158334	-97.104167
52	24662	Herman Cockerham	Withdrawal of Water	292		32.180555	-97.107778
53	3255602	TxDOT	Public Supply	340		32.169444	-97.132778
54	3256201	Presbyterian Children's Home	Unused	470		32.210001	-97.082222
55	3255601	Morris	Unused	305		32.200278	-97.143056
56	3256101	Presbyterian Children's Home	Unused	488		32.208889	-97.084167
57	3256701	J D Turner	Domestic	457		32.163056	-97.105834
58	3256403	Files Valley W.S.C.	Public Supply	2287		32.200556	-97.086389
59	113161	J.C. Rodgers	Domestic	365	No	32.224167	-97.120278
60	3255301	Tom Hensley	Domesitc	200	No	32.214723	-97.13333

Data Source: https://https://www3.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer

FIGURES



LEGEND

- DRY HOLE
- DRY AND ABANDONED GAS
- DRY AND ABANDONED OIL
- GAS WELL
- ABANDONED GAS WELL
- PLUGGED SALTWATER DISPOSAL WELL
- ABANDONED/CANCEL WELL
- BOTTOM HOLE LOCATION
- NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY
- ITASCA LANDFILL PROPERTY BOUDARY
- GEOLOGIC CROSS SECTIONS
- 2.5 MILE AREA OF REVIEW
- FAULT

-N-

API Number
Well Number
Total Depth of Well

SCALE (IN FEET)
0 2000 4000

WSP USA Inc.
16200 Park Row, Ste. 200
Houston TX 77084
TEL: (281) 589-5900

FIGURE VIII-1

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

UNINTERPRETED BASE MAP

DATE: 03/15/2021	CHECKED BY: JT	JOB NO: 192128M
DRAWN BY: WDD	APPROVED BY: GEM	DWG NO:

APPENDICES

APPENDIX

VIII-1 Records and Schematics of Non-Freshwater Artificial Penetrations within 2.5 Miles Area of Review

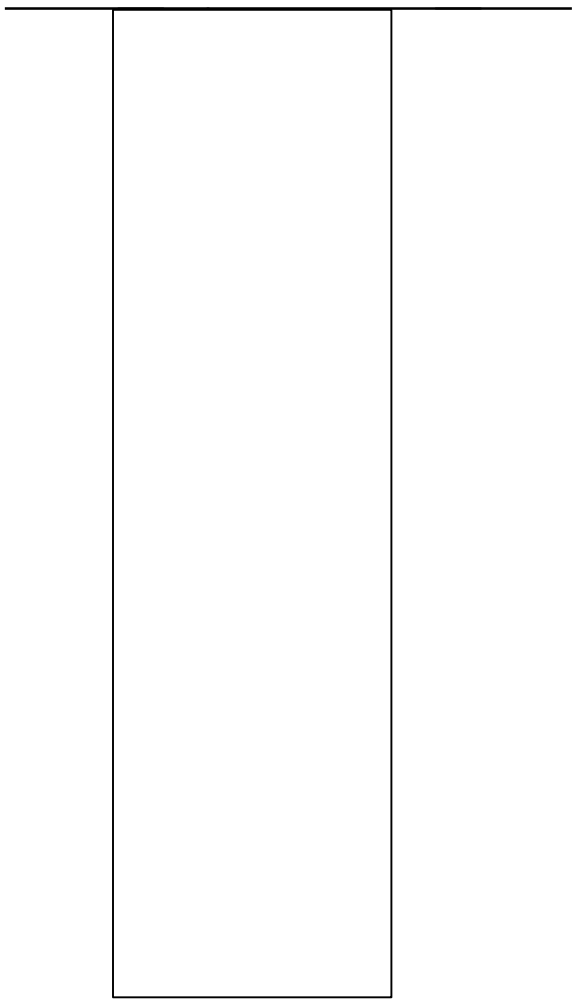
CONTROL NUMBER 1

Artifical Penetration Review

Control Number 1

Operator:	C M Beckner	Status:	D&A - Oil
Lease:	W J Norries Est	Location:	William O Merriwether A-562
Well Number:	1	Mud Filled Wellbore:	
Complete Date:	09/24/1951	Reported Mud Weight:	
Date Plugged:	09/24/1951	API Number:	42-217-00019

NO RECORDS FOUND



T.D. 1006'

Scout Ticket

Tue Dec 08, 2020

42217000190000

General Information

1 W J NORRIS EST

Data Source:	PI	**Country:**	UNITED STATES
API/UWI:	42217000190000	**IC:**	
State/Prov:	TEXAS	**County:**	HILL
Field:	WILDCAT	**Operator:**	BECKNER C M
Current Status:		**Current Operator:**	BECKNER C M
Reg. Well Status/Date:			
Initial Class:	NEW FIELD WILDCAT (WF)	**Final Well Class:**	NEW FIELD WILDCAT-DRY (INCLUDING TEMPORARILY ABANDONED WELL) (WF)
Final Status:	D&A-O	**Target Objective:**	
Permit:	on May 19, 1951	**Hole Direction:**	VERTICAL
First Report Date:	Sep 15, 1951	**Abandonment Date:**	
Projected TD:	2,500 FT	**Projected Formation:**	
Basin:	BEND ARCH-FORT WORTH PROVINCE	**Formation at TD:**	UNKNOWN
		PRODFit Form at TD:	
Play Name:	MISC OUACHITA FOLDED BELT	**Play Type:**	CONVENTIONAL ONSHORE (CONV ONSHR)

Location

Footage NS EW Origin:	1250 FSE 600 FSW TX SUR/POR/GRANT			**Data Source:**	PI
Dist, Abs, Survey:	RR DISTRICT 05 562	MERRIWETHER WILLIAM O			
Blk, Lge, Lot, Labor:					
Township, Section:					
Lat/Long:	+32.2112616 -97.0994938	**Lat/Long Source:**	IH	**Datum:**	NAD27

Dates and Depths

Data Source:	PI		
Spud:	May 29, 1951	**Spud Date Code:**	
TD:	1,006 FT	**TD Date:**	
TVD:		**PlugBack Depth:**	
Formation Code TD:	000UNKWN	**Formation Name TD:**	UNKNOWN
PRODFit Form Code TD:		**PRODFit Form Name TD:**	
Ref. Elevation:	693 FT DF	**KB. Elevation:**	
Ground Elevation:		**LTD:**	
Contractor:			
Completed:	Sep 24, 1951	**Final Drilling:**	
Rig Release Date:		**Rig #:**	
Tool:			

Drilling Journal

Show

Obs	Data Source	Top Depth	Base Depth	Type	Top Form	Base Form	Sample
1	PI	940	980	OSTN			

Dwights Energydata Narrative

Accumulated through 1997

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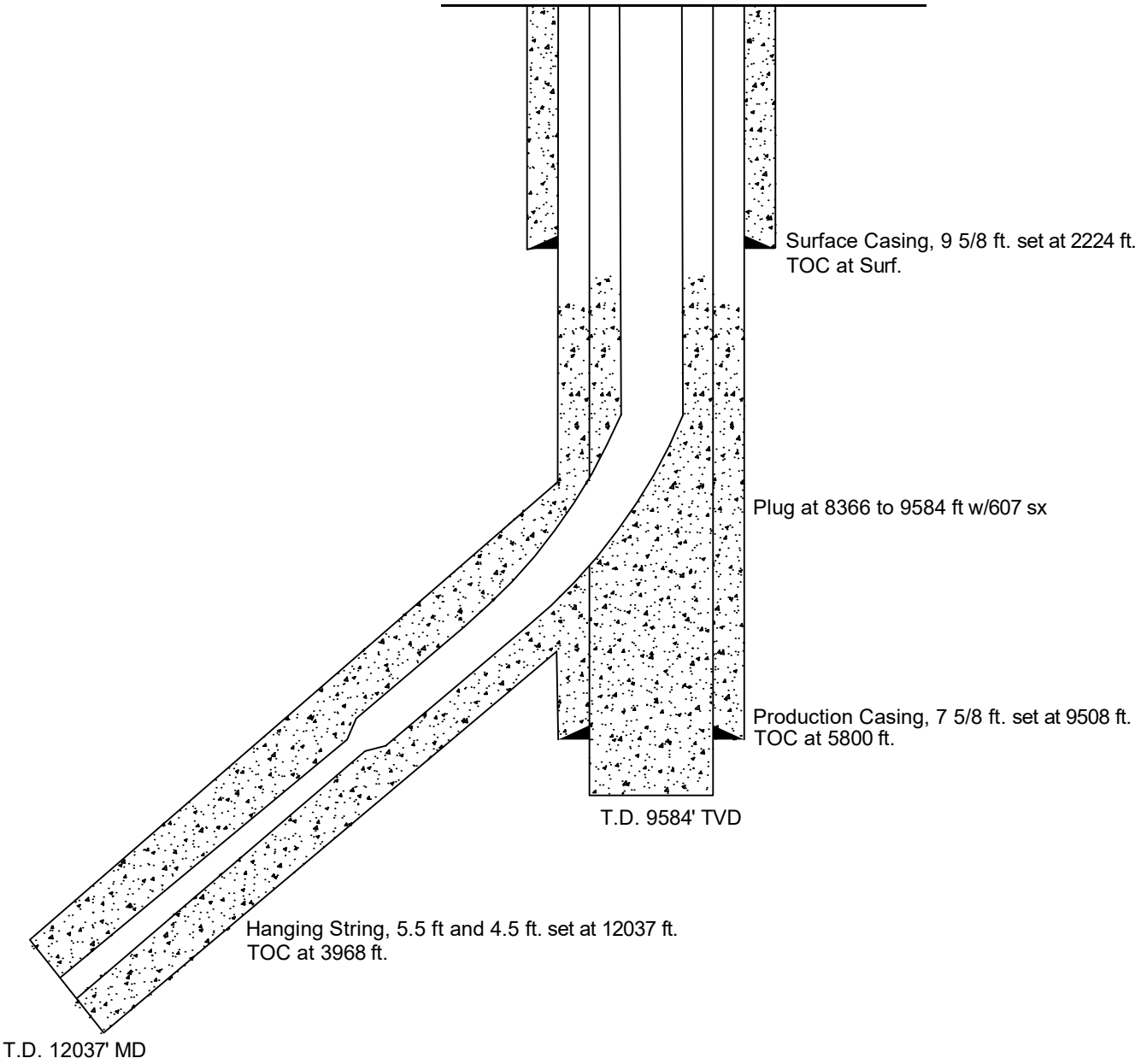
CONTROL NUMBER 2

Artifical Penetration Review

Control Number 2

Operator:	Endeavor Energy Resources LP	Status:	Shut-In TA
Lease:	Presby	Location:	M. Jonett A-472
Well Number:	1H	Mud Filled Wellbore:	Y
Complete Date:	6/14/2008	Reported Mud Weight:	16
Date Plugged:	3/27/2008	API Number:	42-217-30529



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RAILROAD COMMISSION OF TEXAS
Oil and Gas Division

Form G-1
Rev. 4/1/83 DBC1297

483-047

API No. 42- 217-30529

7. RRC District No. ~~05~~ 09

8. RRC Gas ID No. ~~NEW~~ 240792

Gas Well Back Pressure Test, Completion or Recompletion Report, and Log

1. FIELD NAME (as per RRC Records or Wildcat): NEWARK, EAST (BARNETT SHALE)

2. LEASE NAME: PRESBY

9. Well No.: 1H

3. OPERATOR'S NAME (Exactly as shown on Form P-5, Organization Report): ENDEAVOR ENERGY RESOURCES, L.P.

RRC Operator No.: 251726

10. County of well site: HILL

4. ADDRESS: 110 N. MARIENFELD, STE 200
MIDLAND, TX 79701

11. Purpose of filing
- Initial Potential ☐
- Retest ☐
- Reclass ☐
- Well record only (Explain in remarks) ☒

5. Location (Section, Block, and Survey): Sec Blk JONETT, HRS M 472

5b. Distance and direction to nearest town in this county: 4 miles NE from ITASCA

6. If operator has changed within last 60 days, name former operator

12. If workover or reclass, give former field (with reservoir) & Gas ID or oil lease no.

FIELD & RESERVOIR	GAS ID or OIL LEASE #	Oil--O Gas--G	WELL #

13. Pipe Line Connection

14. Completion or recompletion date: 6-14-08

15. Any condensate on hand at time of workover or recompletion? ☐ Yes ☐ No

16. Type of Electric or other Log Run: NONE

Section I — GAS MEASUREMENT DATA

Date of Test

Gas Measurement Method (Check One): Orifice Meter ☐ Flange Taps ☐ Pipe Taps ☐ Positive Choke ☐ Orifice Vent Meter ☐ Pitot Tube ☐ Critical-flow Prover ☐

Gas produced during test: MCF

Run No.	Line Size	Orif. or Choke Size	24 Hr. Coeff. Orif. or Choke	Static P_m or Choke Press	Diff. h_w	Flow Temp. °F	Temp. Factor Ftf	Gravity Factor Fg	Compress Factor Fpv	Volume MCF/DAY
1										
2										
3										
4										

Section II — FIELD DATA AND PRESSURE CALCULATIONS

Gravity (Dry Gas)	Gravity Liquid Hydrocarbon Deg. API	Gas-Liquid Hydro Ratio CF/Bbl	Gravity of Mixture G_{mix} =	Avg. Shut-In Temp. °F	Bottom Hole Temp. °F @ (Depth)

$D_{eff}^{8/3}$ = $\sqrt{T_f}$ = $\sqrt{}$ = $\sqrt{GL}$ = $\sqrt{}$ =

$C = \frac{1118 \times (D_{eff})^{8/3}}{\sqrt{T}}$ = = $\sqrt{\frac{GL}{C}}$ = =

Run No.	Time of Run Min.	Choke Size	Wellhead Press. PSIA P_w	Wellhead Flow Temp. °F	P_w^2 (Thousands)	R	R^2 (Thousands)	P_1	P_w/P_1
Shut-In									
1									
2									
3									
4									

Run No.	F	K	$S = \frac{1}{z}$	E^{ks}	P_f and P_s	P_f^2 and P_s^2 (thousands)	$P_f^2 - P_s^2$ (thousands)
Shut-In							
1							
2							
3							
4							

Angle of Slope
θ .....
n .....

Absolute Open Flow
..... MCF/DAY

RECEIVED RRC OF TEXAS SEP 12 2008 O&G AUSTIN TX

RECEIVED RRC OF TEXAS FEB 03 2010 O&G AUSTIN TX

RECEIVED CENTRAL RECORDS MAR 17 2010 AUSTIN, TEXAS

RECEIVED R.R.C. OF TEXAS AUG 11 2008 OIL & GAS DIVISION KILGORE, TEXAS

WELL TESTER'S CERTIFICATION: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I conducted or supervised this test and that data and facts shown in Sections I and II above are true, correct, and complete, to the best of my knowledge. Bottomhole temperature and the diameter and length of flow string were furnished by the operator of the well.

Signature: Well Tester | Name of Company | RRC Representative

OPERATOR'S CERTIFICATION: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this report, that I prepared or supervised and directed this report, and that data and facts stated therein are true, correct, and complete, to the best of my knowledge.

Vickie L. Gotcher — REGULATORY ANALYST — 08/07/2008 — Tel.: (432) 687-1575

Signature: Operator's representative | Title | Date | A/C Number

MAPPING

MJ 8-2-08

Unperfed, Max O Max ecus Sep 3/5/10

VALID PERMIT

SECTION III — DATA ON WELL COMPLETION AND LOG (Not Required on Retest)

17. Type of Completion: New Well [X] Deepening [ ] Plug Back [ ] Other [ ]

18. Permit to Drill, Plug Back or Deepen — DATE 12/11/2007 — PERMIT NO. 650663 — SEP 15 2008

Rule 37 Exception — CASE NO.

Water Injection Permit — PERMIT NO.

Salt Water Disposal Permit — PERMIT NO.

Other — PERMIT NO.

19. Notice of Intention to Drill this well was filed in Name of: ENDEAVOR ENERGY RESOURCES, L.P.

20. Number of producing wells on this lease in this field (reservoir) including this well: 1

21. Total number of acres in this lease: 532.74

22. Date Plug Back, Deepening, WorkOver or Drilling Operations: Commenced 12/23/2007 Completed 06/14/2008

23. Distance to nearest well, Same Lease & Reservoir:

24. Location of well, relative to nearest lease boundaries of lease on which this well is located: 776 Feet From NW Line and 330 Feet from EAST Line of the PRESBY Lease

25. Elevation (DF, RKB, RT, GR, ETC.): 799

26. Was directional survey made other than inclination (Form W-12)? [X] Yes [ ] No

27. Top of Pay: 9600

28. Total Depth: 12037 md 9235 tvd

29. P.B. Depth: 11995 md 9235 tvd

30. Surface Casing Determined by: Field Rules [ ] Recommendation of T.D.W.R. [X] Railroad Commission (Special) [ ] Dt. of Letter 12/10/2007 Dt. of Letter

31. Is well multiple completion? [ ] Yes [X] No

32. If multiple completion, list all reservoir names (completions in this well) and Oil Lease or Gas ID No.

FIELD & RESERVOIR	GAS ID or OIL LEASE #	Oil-O Gas-G	WELL #

33. Intervals Drilled by: Rotary Tools X Cable Tools

34. Name of Drilling Contractor: BIG DOG DRILLING

35. Cementing Affidavit Attached? [X] Yes [ ] No

36. CASING RECORD (Report All Strings Set in Well)

CASING SIZE	WT #/FT.	DEPTH SET	MULTISTAGE TOOL DEPTH	TYPE & AMOUNT CEMENT (sacks)	HOLE SIZE	TOP OF CEMENT	SLURRY VOL. cu ft.
9 5/8"	36#	2224		1030 CL C	12 1/4"	SURFACE	1730
7 5/8"	33.7#	9508		403 CL H	8 3/4"	5800 CAL	608
5 1/2"	17#	12037		661 CL H	6 1/2"	3968	1086
4 1/2"	11.6#						

37. LINER RECORD

Size	Top	Bottom	Sacks Cement	Screen
				-
				-

38. TUBING RECORD

Size	Depth Set	Packer Set

39. Producing Interval (this completion) Indicate depth of perforation or open hole

From	To
From	To
From	To
From	To

40. ACID, SHOT, FRACTURE, CEMENT SQUEEZE, ETC.

Depth Interval	Amount and Kind of Material Used

41. FORMATION RECORD (LIST DEPTHS OF PRINCIPAL GEOLOGICAL MARKERS AND FORMATION TOPS)

Formations	Depth	Formations	Depth
STRAWN SANDS	2270	ATOKA SAND	5765
MARBLE FALLS	9340	BARNETT SHALE	9600
VIOLA	9950	ELLENBURGER	10000

REMARKS: 8 3/4" PLUG SET AT 8366; 8 3/4" PLUG SET AT 8532.

THIS WELL HAS NOT BEEN PERFORATED OR FRACED AS OF THIS DATE.

front w-15

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Divsion

1. Operator's Name (As shown on Form P-5, Organization Report)	2. RRC Operator No.	3. RRC District No.	4. County of Well Site
Endeavor Energy Resources LP	251726	05	Hill

5. Field Name (Wildcat or exactly as shown on RRC records)	6. API No.	7. Drilling Permit No.
Newark, East (BARNETT SHALE)	42-217-30529	650663

8. Lease Name	9. Rule 37 Case No.	10. Oil Lease/Gas ID No.	11. Well No.
Presby		NEW	1H

CASING CEMENTING DATA:	SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING		MULTI-STAGE CEMENTING PROCESS	
			Single String	Multiple Parallel Strings	Tool	Shoe
12. Cementing Date	12/23/2007					
13. ●Drilling hole size	12 1/4"					
●Est. % wash or hole enlargement						
14 Size of casing (in. O.D.)	9 5/8"					
15. Top of liner (ft.)						
16. Setting depth (ft.)	2224					
17. Number of centralizers used						
18. Hrs. waiting on cement before drill-out						
19. API cement used: No. of sacks	750					
Class	C					
Additives	Remarks					
No. of sacks	280					
Class	C					
Additives	Remarks					
No. of sacks						
Class						
Additives						
20. Slurry pumped: Volume (cu. Ft.)	1358					
Height (ft.)	Surface					
Volume (cu. Ft.)	372					
Height (ft.)	1746					
Volume (cu. Ft.)						
Height (cu. Ft.)						
Volume (cu. Ft.)	1730					
Height (cu. Ft.)	Surface					
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?	YES					

T.N.R.C.C. LETTER DATED 12-10-07
Depth 2150 ft.
13 (b) (2) (G) Exception Dated
Surface Casing ft.
D.V. @ ft.

REMARKS #1 LEAD. 65/35 C-Poz+ 6%D20+ 2%S1+0.25ppsD029 Based on true hole calculations
REMARKS #2 TAIL: Class C+ 2%S1+ 0.25 pps D29

RECEIVED
R.R.C. OF TEXAS
AUG 11 2008
OIL & GAS DIVISION
KILGORE, TEXAS

OVER

back of w-15

CEMENTING TO PLUG AND ABANDON	PLUG # 1	PLUG # 2	PLUG # 3	PLUG # 4	PLUG # 5	PLUG # 6	PLUG # 7	PLUG # 8
23. Cementing date								
24. Size of hole or pipe plugged (in.)								
25. Depth to bottom of tubing or drill pipe (ft.)								
26. Sacks of cement used (each plug)								
27. Slurry volume pumped (cu. ft.)								
28. Calculated top of plug (ft.)								
29. Measured top of plug, if tagged (ft.)								
30. Slurry wt. (lbs/gal)								
31. Type cement								

CEMENTER'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that the cementing of casing and/or the placing of cement plugs in this well as shown in the report was performed by me or under my supervision, and that the cementing data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers cementing data only.

Justin Stafford FS-1	Dowell Schlumberger	J Stafford
Name and title of cementer's representative	Cementing Company	Signature

1004 Louis Street Graham Texas	76450	(940) 549-2000	12/23/2007
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

OPERATOR'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that I have knowledge of the well data and information presented in this report, and that data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers all well data.

VICKIE L. GOTCHER	REGULATORY ANALYST	Vickie L. Gotcher
Typed or printed name of operator's representative	Title	Signature

110 N. MARIENFELD, STE 200 MIDLAND TX 79701	432-687-1575	08/07/08
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

Instructions to Form W-15, Cementing Report

IMPORTANT: Operators and cementing companies must comply with the requirements of the Commission's State Rules 8 (Water Protection), 13 (Casing, Cementing, Drilling, and Completion), and 14 (Well Plugging). For **offshore** operations, see the requirements of Rule 13 (c).

A. **What to file.** An operator should file an original and one copy of the completed Form W-15 for each cementing company used on a well. The cementing of different casing strings on a well by one cementing company may be reported on one form. Form W-15 should be filed with the following:

- An initial oil or gas completion report, **Form W-2 or G-1**, as required by Statewide or special field rules;
- Form W-4, Application for Multiple Completion, if the well is a muliple parallel casing completion; and
- Form W-3, Plugging Record, unless the W-3 is signed by the cementing company representative. When reporting **dry** holes, operators must complete Form **W-15, in addition to Form W-3, to show any casing cemented in the hole.**

B. **Where to file.** The appropriate Commission District Office for the county in which the well is located.

C. **Surface casing.** An operator must set and cement sufficient surface casing to protect all usable-quality water strata, as defined by the Texas Department of Water Resources, Austin. Before drilling a well in any field or area in which no field rules are in effect or in which surface casing requirements are not specified in the applicable rules, an operator must obtain a letter from the Department of Water Resources stating the protection depth. Surface casing should not be set deeper than 200 feet below the specified depth without prior approval from the Commission.

D. **Centralizers.** Surface casing must be centralized at the shoe, above and below a stage collar or diverting tool, if run, and through usable-quality water zones. In nondeviated holes, a centralizer must be placed every fourth joint from the cement shoe to the ground surface or to the bottom of the cellar. All centralizers must meet API specifications.

E. **Exceptions and alternative casing programs.** The District Director may grant an exception to the requirements of Statewide Rule 13. In a written application, an operator must state the reason for the requested exception and outline an alternate program for casing and cementing through the protection depth for strata containing usable-quality water. The District Director may approve, modify, or reject a proposed program. **An operator must obtain approval of any exception before beginning casing and cementing operations.**

F. **Intermediate and production casing.** For specific technical requirements, operators should consult Statewide Rule 13 (b) (3) and (4).

G. **Plugging and abandoning.** Cement plugs must be placed in the wellbore as required by Statewide Rule 14. The District Director may require additional cement plugs. For onshore or inland wells, a 10-foot cement plug must be placed in the top of the well, and the casing must be cut off three feet below the ground surface. All cement plugs, except the top plug, must have sufficient slurry volume to fill 100 feet of hole, plus ten percent for each 1,000 feet of depth from the ground surface to the bottom of the plug.

To plug and abandon a well, operators must use only cementers approved by the Director of Field Operations. Cementing companies, service companies, or operators can qualify as approved cementers by demonstrating that they are able to mix and pump cement in compliance with Commission rules and regulations.

front w-15

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Divsion

1. Operator's Name (As shown on Form P-5, Organization Report)	2. RRC Operator No.	3. RRC District No.	4. County of Well Site
Endeavor Energy Resources LP	251726	05	Hill

5. Field Name (Wildcat or exactly as shown on RRC records)	6. API No.	7. Drilling Permit No.
Newark East (BARNETT SHALE)	42-217-30529	650-663

8. Lease Name	9. Rule 37 Case No.	10. Oil Lease/Gas ID No.	11. Well No.
Presby		NEW	1H

CASING CEMENTING DATA:	SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING		MULTI-STAGE CEMENTING PROCESS	
			Single String	Multiple Parallel Strings	Tool	Shoe
12. Cementing Date						
13. ●Drilling hole size						
●Est. % wash or hole enlargement						
14. Size of casing (in. O.D.)						
15. Top of liner (ft.)						
16. Setting depth (ft.)						
17. Number of centralizers used						
18. Hrs. waiting on cement before drill-out						
19. API cement used: No. of sacks						
Class						
Additives						
No. of sacks						
Class						
Additives						
No. of sacks						
Class						
Additives						
20. Slurry pumped: Volume (cu. Ft.)						
Height (ft.)						
Volume (cu. Ft.)						
Height (ft.)						
Volume (cu. Ft.)						
Height (cu. Ft.)						
Volume (cu. Ft.)						
Height (cu. Ft.)						
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?			NO			

22. REMARKS #1
23. REMARKS #2

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R.R.C. OF TEXAS
AUG 20 2008
OIL & GAS DIVISION
KILGORE, TEXAS

RECEIVED
R.R.C. OF TEXAS
AUG 11 2008
OIL & GAS DIVISION
KILGORE, TEXAS

OVER

back of w-15

CEMENTING TO PLUG AND ABANDON	PLUG # 1	PLUG # 2	PLUG # 3	PLUG # 4	PLUG # 5	PLUG # 6	PLUG # 7	PLUG # 8
23. Cementing date	2/27/2008							
24. Size of hole or pipe plugged (in.)	8.75							
25. Depth to bottom of tubing or drill pipe (ft.)	9584							
26. Sacks of cement used (each plug)	640							
27. Slurry volume pumped (cu. ft.)	607							
28. Calculated top of plug (ft.)	8365.6							
29. Measured top of plug, if tagged (ft.)								
30. Slurry wt. (lbs/gal)	17.5							
31. Type cement	H							

CEMENTER'S CERTIFICATE: I declare under penalties prescribed in Sec 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that the cementing of casing and/or the placing of cement plugs in this well as shown in the report was performed by me or under my supervision, and that the cementing data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers cementing data only.

Alfredo Moreno Field Supervisor 2	Dowell Schlumberger	A. Moreno	
Name and title of cementer's representative	Cementing Company	Signature	
3575 WINDMILL RD	CLEBURNE, TX 76033	(817) 556-4850	2/27/2008
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

OPERATOR'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that I have knowledge of the well data and information presented in this report, and that data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers all well data.

VICKIE L. GOTCHER	REGULATORY ANALYST	Vickie L. Gotcher	
Typed or printed name of operator's representative	Title	Signature	
110 N. MARIENFELD, STE 200	MIDLAND TX 79701	432-687-1575	08/07/08
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

Instructions to Form W-15, Cementing Report

IMPORTANT: Operators and cementing companies must comply with the requirements of the Commission's State Rules 8 (Water Protection), 13 (Casing, Cementing, Drilling, and Completion), and 14 (Well Plugging). For **offshore** operations, see the requirements of Rule 13 (c).

A. **What to file.** An operator should file an original and one copy of the completed Form W-15 for each cementing company used on a well. The cementing of different casing strings on a well by one cementing company may be reported on one form. Form W-15 should be filed with the following:

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- Form **W-4**, Application for Multiple Completion, if the well is a muliple parallel casing completion; and
- Form **W-3**, Plugging Record, unless the W-3 is signed by the cementing company representative. When reporting **dry** holes, operators must complete Form **W-15, in addition to Form W-3, to show any casing cemented in the hole.**

B. **Where to file.** The appropriate Commission District Office for the county in which the well is located.

C. **Surface casing.** An operator must set and cement sufficient surface casing to protect all usable-quality water strata, as defined by the Texas Department of Water Resources, Austin. Before drilling a well in any field or area in which no field rules are in effect or in which surface casing requirements are not specified in the applicable rules, an operator must obtain a letter from the Department of Water Resources stating the protection depth. Surface casing should not be set deeper than 200 feet below the specified depth without prior approval from the Commission.

D. **Centralizers.** Surface casing must be centralized at the shoe, above and below a stage collar or diverting tool, if run, and through usable-quality water zones In nondeviated holes, a centralizer must be placed every fourth joint from the cement shoe to the ground surface or to the bottom of the cellar. All centralizers must meet API specifications.

E. **Exceptions and alternative casing programs.** The District Director may grant an exception to the requirements of Statewide Rule 13. In a written application, an operator must state the reason for the requested exception and outline an alternate program for casing and cementing through the protection depth for strata containing usable-quality water. The District Director may approve, modify, or reject proposed program. **An operator must obtain approval of any exception before beginning casing and cementing operations.**

Schlumberger Private

F. **Intermediate and production casing.** For specific technical requirements, operators should consult Statewide Rule 13 (b) (3) and (4).

G. **Plugging and abandoning.** Cement plugs must be placed in the wellbore as required by Statewide Rule 14. The District Director may require additional cement plugs. For onshore or inland wells, a 10-foot cement plug must be placed in the top of the well, and the casing must be cut off three feet below the ground surface. All cement plugs, except the top plug, must have sufficient slurry volume to fill 100 feet of hole, plus ten percent for each 1,000 feet of depth from the ground surface to the bottom of the plug.

To plug and abandon a well, operators must use only cementers approved by the Director of Field Operations. Cementing companies, service companies, or operators can qualify as approved cementers by demonstrating that they are able to mix and pump cement in compliance with Commission rules and regulations.

front w-15

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Divsion

1. Operator's Name (As shown on Form P-5, Organization Report)	2. RRC Operator No.	3. RRC District No.	4. County of Well Site
Endeavor Energy			Hill

5. Field Name (Wildcat or exactly as shown on RRC records)	6. API No.	7. Drilling Permit No
NEWARK EAST	42-217-~~360509~~ 30529	650663

8. Lease Name	9. Rule 37 Case No	10. Oil Lease/Gas ID No.	11. Well No.
Presby			1H

CASING CEMENTING DATA:	SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING		MULTI-STAGE CEMENTING PROCESS	
			Single String	Multiple Parallel Strings	Tool	Shoe
12. Cementing Date						
13. ●Drilling hole size						
●Est. % wash or hole enlargement						
14. Size of casing (in. O.D.)						
15. Top of liner (ft.)						
16. Setting depth (ft.)						
17. Number of centralizers used						
18. Hrs waiting on cement before drill-out						
19. API cement used: No.of sacks						
Class						
Additives						
No. of sacks						
Class						
Additives						
No. of sacks						
Class						
Additives						
20.Slurry pumped:Volume(cu. Ft.)						
Height (ft)						
Volume (cu. Ft)						
Height (ft)						
Volume (cu. Ft.)						
Height (cu. Ft.)						
Volume (cu. Ft.)						
Height (cu. Ft.)						
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?						

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REMARKS KOP: 0.1 % BWOB D167 + 1.5 % BWOB D065 + 94 lbs/sk D909 + 0.015 gal/sk D801 Based on true hole calculations

OVER

back of W-15

CEMENTING TO PLUG AND ABANDON	PLUG # 1	PLUG # 2	PLUG # 3	PLUG # 4	PLUG # 5	PLUG # 6	PLUG # 7	PLUG # 8
23. Cementing date	3/27/2008							
24. Size of hole or pipe plugged (in.)	8 3/4							
25. Depth to bottom of tubing or drill pipe (ft.)	9057							
26. Sacks of cement used (each plug)	350							
27. Slurry volume pumped (cu. ft.)	59							
28. Calculated top of plug (ft.)	8532							
29. Measured top of plug, if tagged (ft.)								
30. Slurry wt. (lbs/gal)	17.5							
31. Type cement	H							

CEMENTER'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that the cementing of casing and/or the placing of cement plugs in this well as shown in the report was performed by me or under my supervision, and that the cementing data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers cementing data only.

KEVIN PUES FIELD SPECIALIST	Dowell Schlumberger	
Name and title of cementer's representative	Cementing Company	Signature

3575 Windmill Road	Cleburne	Texas	76033	(817) 556-4850	3/27/2008
Address	City,	State,	Zip Code	Tel.: Area Code Number	Date: mo. day yr.

OPERATOR'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that I have knowledge of the well data and information presented in this report, and that data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers all well data.

VICKIE L. GOTCHER	REGULATORY ANALYST	Vickie L. Gotcher
Typed or printed name of operator's representative	Title	Signature

110 N. MARIENFELD, STE. 200	MIDLAND	TX	79701	432-687-1575	08/07/08
Address	City,	State,	Zip Code	Tel.: Area Code Number	Date: mo. day yr.

Instructions to Form W-15, Cementing Report

IMPORTANT: Operators and cementing companies must comply with the requirements of the Commission's State Rules 8 (Water Protection), 13 (Casing, Cementing, Drilling, and Completion), and 14 (Well Plugging). For **offshore** operations, see the requirements of Rule 13 (c).

A. **What to file.** An operator should file an original and one copy of the completed Form W-15 for each cementing company used on a well. The cementing of different casing strings on a well by one cementing company may be reported on one form. Form W-15 should be filed with the following:

- An initial oil or gas completion report, **Form W-2 or G-1**, as required by Statewide or special field rules;
- Form **W-4**, Application for Multiple Completion, if the well is a muliple parallel casing completion; and
- Form **W-3**, Plugging Record, unless the W-3 is signed by the cementing company representative. When reporting **dry** holes, operators must complete Form **W-15, in addition to Form W-3, to show any casing cemented in the hole.**

B. **Where to file.** The appropriate Commission District Office for the county in which the well is located.

C. **Surface casing.** An operator must set and cement sufficient surface casing to protect all usable-quality water strata, as defined by the Texas Department of Water Resources, Austin. Before drilling a well in any field or area in which no field rules are in effect or in which surface casing requirements are not specified in the applicable rules, an operator must obtain a letter from the Department of Water Resources stating the protection depth. Surface casing should not be set deeper than 200 feet below the specified depth without prior approval from the Commission.

D. **Centralizers.** Surface casing must be centralized at the shoe, above and below a stage collar or diverting tool, if run, and through usable-quality water zones. In nondeviated holes, a centralizer must be placed every fourth joint from the cement shoe to the ground surface or to the bottom of the cellar. All centralizers must meet API specifications.

E. **Exceptions and alternative casing programs.** The District Director may grant an exception to the requirements of Statewide Rule 13. In a written application, an operator must state the reason for the requested exception and outline an alternate program for casing and cementing through the protection depth for strata containing usable-quality water. The District Director may approve, modify, or reject a proposed program. **An operator must obtain approval of any exception before beginning casing and cementing operations.**

F. **Intermediate and production casing.** For specific technical requirements, operators should consult Statewide Rule 13 (b) (3) and (4).

G. **Plugging and abandoning.** Cement plugs must be placed in the wellbore as required by Statewide Rule 14. The District Director may require additional cement plugs. For onshore or inland wells, a 10-foot cement plug must be placed in the top of the well, and the casing must be cut off three feet below the ground surface. All cement plugs, except the top plug, must have sufficient slurry volume to fill 100 feet of hole, plus ten percent for each 1,000 feet of depth from the ground surface to the bottom of the plug.

To plug and abandon a well, operators must use only cementers approved by the Director of Field Operations. Cementing companies, service companies, or operators can qualify as approved cementers by demonstrating that they are able to mix and pump cement in compliance with Commission rules and regulations.

front w-15

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Divsion

1. Operator's Name (As shown on Form P-5, Organization Report)	2. RRC Operator No.	3. RRC District No.	4. County of Well Site
ENDEAVOR ENERGY RESOURCES, L.P.	251726	05	Hill

5. Field Name (Wildcat or exactly as shown on RRC records)	6. API No.	7. Drilling Permit No.
Newark East (BARNETT SHALE)	42-217-30529	650663

8. Lease Name	9. Rule 37 Case No.	10. Oil Lease/Gas ID No.	11. Well No.
Presby		NEW	1H

CASING CEMENTING DATA:	SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING		MULTI-STAGE CEMENTING PROCESS	
			Single String	Multiple Parallel Strings	Tool	Shoe
12. Cementing Date			5/2/2008			
13. ●Drilling hole size			8 3/4"			
●Est. % wash or hole enlargement						
14. Size of casing (in. O.D.)			7 5/8			
15. Top of liner (ft.)						
16. Setting depth (ft.)			9508			
17. Number of centralizers used			0			
18. Hrs. waiting on cement before drill-out			24			
19. API cement used: No. of sacks			231			
Class			H			
Additives			Remarks			
No. of sacks			172			
Class			H			
Additives			Remarks			
No. of sacks						
Class						
Additives						
20. Slurry pumped: Volume (cu. Ft.)			393			
Height (ft.)			5572			
Volume (cu. Ft.)			215			
Height (ft.)			8172			
Volume (cu. Ft.)						
Height (cu. Ft.)						
Volume (cu. Ft.)			608			
Height (cu. Ft.)			5572			
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?			No			

REMARKS #1 Lead: + 5% D020+0.1%D013+0.1% D065+0.2% D046 Based on true hole calculations
REMARKS #2 TAIL: 0.2% D065+0.25% D167+3% D020+0.1% D013+1% D174

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back of w-15

CEMENTING TO PLUG AND ABANDON	PLUG #1	PLUG #2	PLUG #3	PLUG #4	PLUG #5	PLUG #6	PLUG #7	PLUG #8
23. Cementing date								
24. Size of hole or pipe plugged (in.)								
25. Depth to bottom of tubing or drill pipe (ft.)								
26. Sacks of cement used (each plug)								
27. Slurry volume pumped (cu. ft.)								
28. Calculated top of plug (ft.)								
29. Measured top of plug, if tagged (ft.)								
30. Slurry wt. (lbs/gal)								
31. Type cement								

CEMENTER'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that the cementing of casing and/or the placing of cement plugs in this well as shown in the report was performed by me or under my supervision, and that the cementing data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers cementing data only.

JUSTIN STAFFORD FIELD SPECIALIST	Dowell Schlumberger	
Name and title of cementer's representative	Cementing Company	Signature

3575 Windmill Rd.	Cleburne	Texas	76033	(817) 556-58501	5/2/2008
Address	City,	State,	Zip Code	Tel.: Area Code Number	Date: mo. day yr.

OPERATOR'S CERTIFICATE: I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this certification, that I have knowledge of the well data and information presented in this report, and that data and facts presented on both sides of this form are true, correct, and complete, to the best of my knowledge. This certification covers all well data.

VICKIE L. GOTCHER	REGULATORY ANALYST	Vickie L. Gotcher
Typed or printed name of operator's representative	Title	Signature

110 N. MARIENFELD, STE 200	MIDLAND	TX	79701	432-687-1575	08/07/08
Address	City,	State,	Zip Code	Tel.: Area Code Number	Date: mo. day yr.

Instructions to Form W-15, Cementing Report

IMPORTANT: Operators and cementing companies must comply with the requirements of the Commission's State Rules 8 (Water Protection), 13 (Casing, Cementing, Drilling, and Completion), and 14 (Well Plugging). For **offshore** operations, see the requirements of Rule 13 (c).

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- Form **W-4**, Application for Multiple Completion, if the well is a muliple parallel casing completion; and
- Form **W-3**, Plugging Record, unless the W-3 is signed by the cementing company representative. When reporting **dry** holes, operators must complete Form **W-15, in addition to Form W-3, to show any casing cemented in the hole.**

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E. **Exceptions and alternative casing programs.** The District Director may grant an exception to the requirements of Statewide Rule 13. In a written application, an operator must state the reason for the requested exception and outline an alternate program for casing and cementing through the protection depth for strata containing usable-quality water. The District Director may approve, modify, or reject a proposed program. **An operator must obtain approval of any exception before beginning casing and cementing operations.**

Schlumberger Private

F. **Intermediate and production casing.** For specific technical requirements, operators should consult Statewide Rule 13 (b) (3) and (4).

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front w-15

Form W-15
Cementing Report
Rev. 4/1/83
483-045

RAILROAD COMMISSION OF TEXAS
Oil and Gas Divsion

1. Operator's Name (As shown on Form P-5, Organization Report)	2. RRC Operator No.	3. RRC District No.	4. County of Well Site
ENDEAVOR ENERGY RESOURCES, LP	251726	05 5	Hill

5. Field Name (Wildcat or exactly as shown on RRC records)	6. API No.	7. Drilling Permit No.
Newark, East (BARNETT SHALE)	42-217-30529	650663

8. Lease Name	9. Rule 37 Case No.	10. Oil Lease/Gas ID No.	11. Well No.
Presby		NEW	1H

CASING CEMENTING DATA:	SURFACE CASING	INTER-MEDIATE CASING	PRODUCTION CASING		MULTI-STAGE CEMENTING PROCESS	
			Single String	Multiple Parallel Strings	Tool	Shoe
12. Cementing Date			6/14/2008			
13. ●Drilling hole size			6 1/2"			
●Est. % wash or hole enlargement			15%			
14. Size of casing (in. O.D.)			5 1/2 / 4 1/2			
15. Top of liner (ft.)						
16. Setting depth (ft.)			12,037			
17. Number of centralizers used			0			
18. Hrs. waiting on cement before drill-out			24			
19. API cement used: No.of sacks			80			
Class			H			
Additives			Remarks			
No. of sacks			581			
Class			H			
Additives			Remarks			
No. of sacks						
Class						
Additives						
20.Slurry pumped:Volume(cu. Ft.)			98			
Height (ft)			559			
Volume (cu. Ft.)			988			
Height (ft.)			2887			
Volume (cu. Ft.)						
Height (cu Ft.)						
Volume (cu. Ft.)			1086			
Height (cu. Ft.)						
21. Was cement circulated to ground surface (or bottom of cellar) outside casing?			NO			

22. REMARKS #1 4 % BWOB D020 + 0.1 % BWOB D065 + 0.3 % BWOB D013 + 0.25 % BWOB D167 + 47.064 lbs/sk D909 +
23.REMARKS #2 50 % BWOB D151 + 3 % BWOB D020 + 0.25 % BWOB D167 + 0.3 % BWOB D065 + 0.25 % BWOB D079 + 0

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CEMENTING TO PLUG AND ABANDON	PLUG # 1	PLUG # 2	PLUG # 3	PLUG # 4	PLUG # 5	PLUG # 6	PLUG # 7	PLUG # 8
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31. Type cement								

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Alfredo Moreno Field Supervisor 2	Dowell Schlumberger	A. Moreno	
Name and title of cementer's representative	Cementing Company	Signature	
3575 WINDMILL RD	CLEBURNE, TX 76033	(817) 556-4850	6/14/2008 1
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

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VICKIE L. GOTCHER	REGULATORY ANALYST	Vickie L. Gotcher	
Typed or printed name of operator's representative	Title	Signature	
110 N. MARIENFELD, STE. 200	MIDLAND, TX 79701	432-687-1575	08/07/08
Address	City, State, Zip Code	Tel.: Area Code Number	Date: mo. day yr.

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Schlumberger Private

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Form P-15
(5-5-71)
DBC0697

STATEMENT OF PRODUCTIVITY OF ACREAGE ASSIGNED TO PRORATION UNITS

The undersigned states that he is authorized to make this statement; that he has knowledge of the facts concerning the ENDEAVOR ENERGY RESOURCES, L.P. (OPERATOR), PRESBY (LEASE) 650663 NEW, No. 1H (WELL); that such well is completed in the NEWARK, EAST (BARNETT SHALE) Field, HILL County, Texas and that the acreage claimed, and assigned to such well for proration purposes as authorized by special rule and as shown on the attached certified plat embraces _____ 532.74 acres which can reasonably be considered to be productive of hydrocarbons.

- CERTIFICATE -

I declare under penalties prescribed in Sec. 91.143, Texas Natural Resources Code, that I am authorized to make this report, that this report was prepared by me or under my supervision and direction, and that data and facts stated therein are true, correct, and complete, to the best of my knowledge.

Date 08/07/2008 Signature Vicki L. Gotcher

Telephone _____ (AREA CODE) (432) 687-1575 Title REGULATORY ANALYST

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PERMIT PLAT
OF
PRESBY # 1H
IN THE
JOHN BEACH SURVEY, ABSTRACT 51,
WILLIAM O. MERRIWETHER SURVEY, ABSTRACT 562,
M. G. HERRERRA SURVEY, ABSTRACT 363 AND THE
MATTHEW JONETT SURVEY, ABSTRACT 472
HILL COUNTY, TEXAS
532.74 ACRES
FOR ENDEAVOR ENERGY RESOURCES, L.P.

Surface Hole Location (SHL)
NAD 83 TX. SPC
Lat. = 32°12'24.278657" N
Long. = 97°04'36.953923" W
N. = 6761139.31339
E. = 2408659.44378
Elev. = 799

Point of Penetration (POP)
NAD 83 TX. SPC
Lat. = 32°12'22.909161" N
Long. = 97°04'42.545899" W
N. = 6760994.423953
E. = 2408180.896968

Bottom Hole Location (BHL)
NAD 83 TX. SPC
Lat. = 32°12'14.839513" N
Long. = 97°05'15.489391" W
N. = 6760140.825286
E. = 2405361.595893

SZURGOT & PEEDE
LAND SURVEYORS, LTD.
125 N. COVINGTON STREET
P.O. BOX 533
HILLSBORO, TEXAS 76645
Ph 254/582-3231
Fax 254/582-3234
e-mail: szurveyors@hillsboro.net

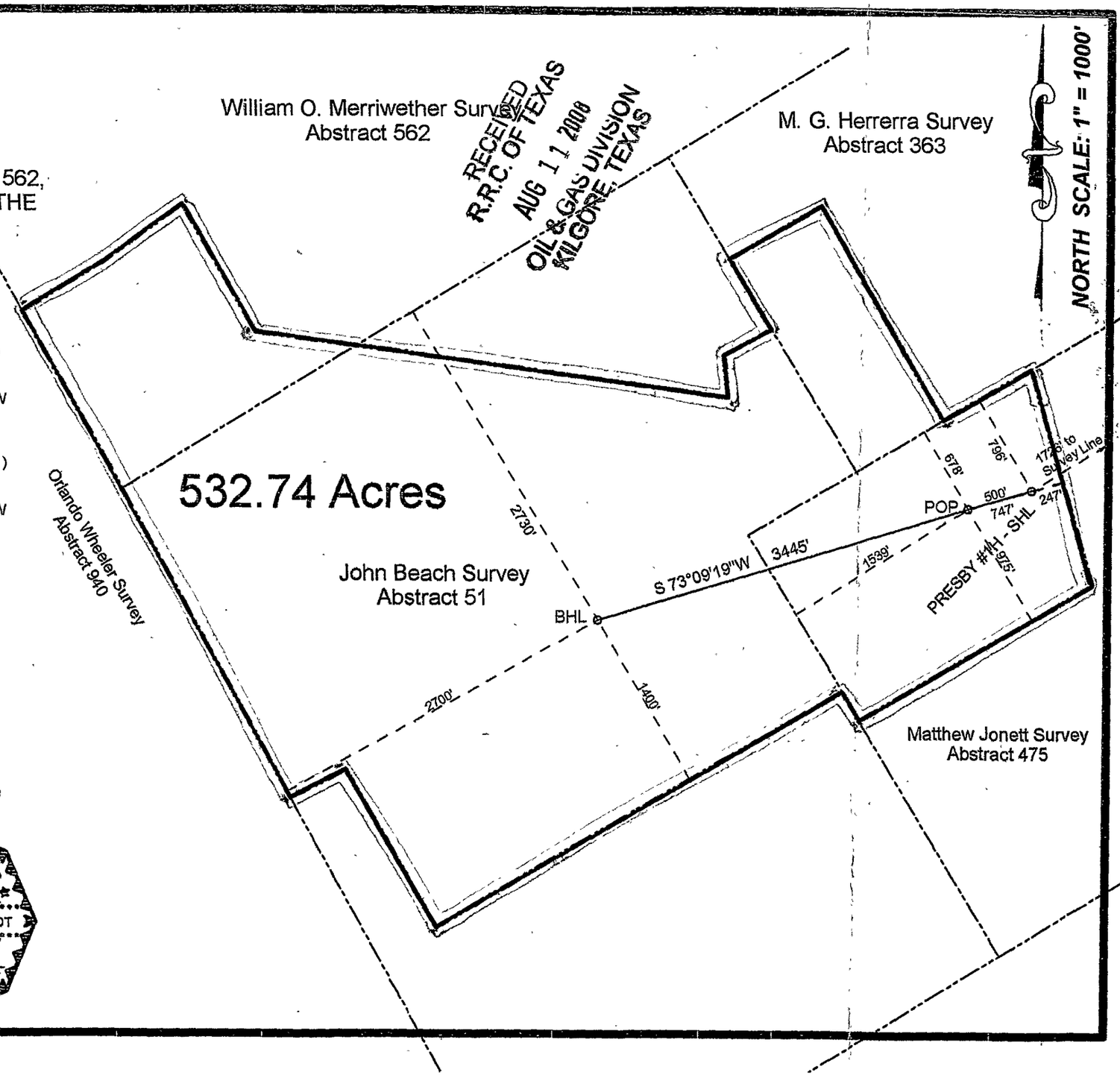
Surveyors Certificate:

This plat represents an actual survey made on the ground under my supervision on NOVEMBER 2, 2007, and is true and correct to the best of my knowledge.

Donald B. Szurgot
Registered Professional Land Surveyor
No. 1780, State of Texas

STATE OF TEXAS
REGISTERED
DONALD B. SZURGOT
1780
PROFESSIONAL
LAND SURVEYOR

J. N. 110407.1 mlh



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RAILROAD COMMISSION OF TEXAS Oil and Gas Division	ELECTRIC LOG STATUS REPORT	FORM L-1 Rev. 01-2007 DBC0308

Instructions

When to File Form L-1:
- with Forms G-1, W-2, and GT-1 for new and deepened gas, oil, and geothermal wells
- with Form W-3 for plugged dry holes
- when sending in a log which was held under a request for confidentiality and the period for confidentiality has not yet expired.

When is Form L-1 NOT required:
- with Forms W-2, G-1, and GT-1 filed for injection wells, disposal wells, water supply wells, service wells, re-test wells, re-classifications, and plugbacks of oil, gas or geothermal wells
- with Form W-3 for plugging of other than a dry hole

Where to File Form L-1:
- with the appropriate Commission district office

Filling out Form L-1:
- Section I and the signature section must be filled out for all wells
- complete only the appropriate part of Section II

Type of log required:
- any wireline survey run for the purpose of obtaining lithology, porosity, or resistivity information
- no more than one such log is required but it must be of the subject well
- if such log is NOT run on the subject well, do NOT substitute any other type of log; just select Section II, Part A below

SEE REVERSE SIDE

SECTION I. IDENTIFICATION

Operator Name:	ENDEAVOR ENERGY RESOURCES, L.P.	District No. 05	Completion Date: 06/14/2008
Field Name	NEWARK, EAST (BARNETT SHALE)	Drilling Permit No. 650663	
Lease Name	PRESBY	Lease/ID No. NEW	Well No. 1H
County	HILL	API No. 42- 217-30529	

SECTION II. LOG STATUS (Complete either A or B)

☒ A. BASIC ELECTRIC LOG NOT RUN

☐ B. BASIC ELECTRIC LOG RUN. (Select one)

☐ 1. Confidentiality is requested and a copy of the header for each log that has been run on the well is attached.

☐ 2. Confidentiality already granted on basic electric log covering this interval (applicable to deepened wells only).

☐ 3. Basic electric log covering this interval already on file with Commission (applicable to deepened wells only).

☐ 4. Log attached to (select one):

☐ (a) Form L-1 (this form). If the company/lease name on log is different from that shown in Section I, please enter name on log here: _____

Check here if attached log is being submitted after being held confidential. ☐

☐ (b) Form P-7, Application for Discovery Allowable and New Field Designation.

☐ (c) Form W-4, Application for Multiple Completion: Lease or ID No(s). _____ Well No(s). _____

RECEIVED
R.R.C. OF TEXAS
AUG 11 2008
OIL & GAS DIVISION
KILGORE, TEXAS

Vickie L. Gotcher Signature	REGULATORY ANALYST Title
VICKIE L. GOTCHER Name (print)	(432)687-1575 Phone 08/07/2008 Date

-FOR RAILROAD COMMISSION USE ONLY-

DEPTH OF USABLE-QUALITY GROUND WATER TO BE PROTECTED

406

PLEASE DO NOT STAPLE

PLEASE READ ALL INSTRUCTIONS

The information requested is essential in order for this agency to provide an appropriate response. Please allow for receipt of this form in our offices at least two weeks before your operation begins. Due to the volume of these requests, at times, it may be difficult for us to handle telephone inquiries. Complete, keep the bottom sheet (goldenrod) for your files, and mail the top 3 sheets of the 4-sheet set of carbon-backed forms with a map to the address below. One sheet bearing our response will be returned to you. Another will be sent to the appropriate district office of the Railroad Commission. Individuals are entitled to request and review their personal information that the agency gathers on its forms. If you have questions on how to fill out this form or about the Surface Casing program, please contact us at 512/239-0515.

RECEIVED
DEC 10 2007
TCEQ

Surface Casing - MC 151
P.O. Box 13087
Austin, TX 78711-3087

Date 12/10/07 TCEQ File No.: SC- 406

MILLER CONSULTING, INC.
(512) 478-3456
AMIFF: (512) 478-3876

Vickie Gotcher 432-262-4013
Name of person preparing this request & phone No. (with area code)

Endeavor Energy Resources L.P.
Company (operator's name as on RRC form W-1)

110 N. Marienfeld, Suite 200
Mailing Address

Midland, TX 79701
City and State ZIP Code

FOR TCEQ USE ONLY

ALWAYS INCLUDE A MAP SHOWING YOUR WELL SITE AND ALL SURROUNDING SURVEYS

TYPE OR PRINT IN INK

COUNTY Hill Survey Name Jonett, Hrs M
Block No. ____ Township ____ Section or Survey No. ____ (or) Lot No. ____
Abstract No. A- 472 LEASE Name Presby Well No. 1H
Distances, in feet, and directions measured at right angles from each of two intersecting ☐ Section or ☐ Survey lines (NOT LEASE LINES) 776 feet from NW line and 1807 feet from NE line.
Distance (in miles) and direction from a nearby town in this County (name the town)
4 miles NE of Itasca

12/10/07

THE ABOVE INFORMATION IN THIS BLOCK MUST BE COMPLETE AND CORRECT

API # ____ RRC Lease No. ____ RRC Dist. No. 09/05
GPS Coord.(long/lat or X-Y state plane) N: 6761115.261743 E: 2408580.005009 NAD 83

Elevation 803' Total Depth 10,000' Geologic Fm. at T.D. ____
Purpose of the Request: ☒ New Drill ☐ Re-entry ☐ Plug & Abandon ☐ Other (specify) ____
Is this an amended request? ☐ Yes ☒ No Previous File No. for this well: SC- ____

☐ Log included of same or nearby well (The applicable type of well log that shows the aquifers.) Please provide a location map or API# for attached log.

ALWAYS attach the electric log of any well that is to be reentered.

Additional remarks: ____

DO NOT WRITE HERE
FOR TCEQ USE ONLY

To protect usable-quality ground water at this location, the TEXAS COMMISSION ON ENVIRONMENTAL QUALITY recommends:

CO-HILL,SUR-JONETT M.,LSE-PRESBY,A-472,#6/2150

The interval from the land surface to 20 feet below the base of the Cretaceous-age beds must be protected. The base of the Cretaceous is estimated to occur at a depth of 2150 feet.

RECEIVED
R.R.C. OF TEXAS
AUG 11 2008
OIL & GAS DIVISION
KILGORE, TEXAS

STATE OF TEXAS
Mark R. Vining
PROFESSIONAL GEOSCIENTIST

Very truly yours,

Mark R. Vining, P.G.

Date December 10, 2007

Geologist, Surface Casing, TCEQ typed by TCEQ

NOTE: Unless stated otherwise, this recommendation is intended to apply only to the subject well and not for area-wide use. Approval of the well-completion methods for protection of this ground water falls under the jurisdiction of the Railroad Commission of Texas. This recommendation is intended for normal drilling, production, and plugging operations only. It does not apply to saltwater disposal operations into a nonproductive zone (RRC Form W-14).

TCEQ-0051 (Rev. 05-10-2006)

RAILROAD COMMISSION OF TEXAS
Oil and Gas Division
Compliance Section

NOTIFICATION FORM FOR
SURFACE CASING 2008-09-12655

D-N
rev.3/02

(WATER PROTECTION STRING)

NOTIFICATION: INDUSTRY ☒ PUBLIC ☐ CALL ☒ LETTER ☐

PERSON CALLING LEE SPARKS DATE 12/22/07 TIME 1:56PM

TITLE/CO ENDEAVOR PHONE 940 231 1086

OPERATOR ENDEAVOR ENERGY RESOURCES LP 251926

LEASE/FACILITY PRESBY PERMIT NO.650663

WELL NO. 1-H OTHERLESLIE

FIELD NEWARK EAST BARNETT SHALE

COUNTY HILL 19

DRIVING DIRECTIONS TO WELLSITE FROM NEAREST TOWN: (Do not exceed 5 lines of data)

HILLSBOROUGH. NORTH OUT OF HILLBOUROUGH ON 35. EXT 8(HWY66). GO EAST 4.5 MILES. COME TO CTY RD 4434. TK RT 1/2 MILE , TK RT ON THE CTY RD AND THE WELL IS ON THE HILL.

PLEASE CHECK APPROPRIATE JOB:

SCHEDULED DATE FOR CEMENTING 12/22/07 TIME OF JOB: 10PM

HOW MANY FEET: 2224 OF 0 9 5/8" CASING TO BE SET

HOW MANY SACKS OF CEMENT: LEAD: 745 TAIL: 280

NAME OF CEMENT COMPANY SCHLUMBERGER

ORIGINAL

SC# ON TNRCC FORM (AT TOP RIGHT OF FORM) 406

DEPTH OF USABLE QUALITY GROUND WATER TO BE PROTECTED ON TNRCC FORM 2150 FT

SPUD DATE 12/18/07 7PM

NAME OF DRILLING CONTRACTOR: BIG DOG RIG NO. 16

DV TOOL: N/A OPEN HOLE SIZE: 13 1/4

VICTOR G. CARRILLO, CHAIRMAN
ELIZABETH A. JONES, COMMISSIONER
MICHAEL L. WILLIAMS, COMMISSIONER

TOMMIE SEITZ
DIRECTOR, OIL AND GAS DIVISION
GIL BUJANO, P.E.
ASSISTANT DIRECTOR, TECHNICAL PERMITTING

RAILROAD COMMISSION OF TEXAS

OIL AND GAS DIVISION

API # 217-30529
02/03/2010–03/05/2010

February 03, 2010

ENDEAVOR ENERGY RESOURCES L.P.
ATTN: REGULATORY DEPARTMENT
110 N MARIENFELD ST SUITE 200
MIDLAND TX 79701

RE: PRESBY LEASE
WELL NO. 1H
NEWARK, EAST (BARNETT SHALE) (#65280200) FIELD
HILL COUNTY, DISTRICT 09, TEXAS
DRILLING PERMIT NO. 650663
API NO. 217-30529

A review of the completion report by the Austin Office for the referenced permit revealed that this office has not received all of the directional surveys required for the referenced well. Please be advised that an allowable cannot be assigned until all directional surveys have been submitted to the Austin Office. The surveying company making the directional survey must file the survey by registered, certified, or overnight mail to the Austin Office as required by Statewide Rule 12.

The following directional survey(s) has/have been filed:
VAUGHN ENERGY SERVICES 0–9645 ft (received 07/23/2008)
Directional surveys must be filed for the following depths:
9645–12037

All directional surveys, unless otherwise specified by the commission, shall be either single shot surveys or multi-shot surveys with the shot points not more than 200 feet apart, beginning within 200 feet of the surface, and the bottom hole location must be oriented both to the surface location and to the lease lines (or unit lines in cases of pooling).

Please attach a copy of this letter with the requested information and submit within 30 days of the date of this letter.

You may contact Pam Johns at 512-463-6899 or Scott Rosenquist at 512-475-2307 should you have any questions.

Sincerely,

Scott Rosenquist

Scott Rosenquist
Eng. Specialist III
Technical Permitting

cc: District Office 09
Pam Thompson, Compliance Analyst

VES
VAUGHN ENERGY SERVICES
A GYRO TECHNOLOGIES INC. COMPANY

PO Box 261021
Corpus Christi, Texas 78426
(361) 384-0602 • (800) 606-GYRO • Fax (361) 384-0612

April 24, 2008

RECEIVED
RRC OF TEXAS
JUL 23 2008
O&G
AUSTIN TX

Railroad Commission Of Texas
Oil & Gas Division
P.O. Box 12967
Capitol Station
Austin, Texas 78711

Attention: Ms. Pam Johns

RE: Endeavor Energy Resources, L.P.
Presby #1H
Field: Newark, East (Barnett Shale)
Survey: Jonett, HRS M Abstract No. 472
Hill County, Texas
API# 42-217-30529

Ms. Johns:

Enclosed, please find the original and one copy of the survey performed on the above referenced well by Vaughn Energy Services, LLC. (P-5 No. 884130). Other information required by your office is as follows:

Name & Title	Drainhole Number	Surveyed Depths	Dates Performed	Type Of Survey
Dale Jakeway Surveyor	Original Hole	0' to 9645' MD	2-9-08	Gyroscopic

A certified plat on which the bottom hole location is oriented both to the surface location and to the lease line is attached to the survey report. If any other information is required, please contact the undersigned at the letterhead address and phone number.

Sincerely,

Neisha Havelka

Company: ENDEAVOR RESOURCES
Well: PRESBY #1-H
Location: HILL COUNTY
Rig Name: BIG DOG #16
State/County: TEXAS/HILL COUNTY
Latitude: 32.21
GRID North is 0.23 Degrees East of True North
VS-Azi: 0.00 Degrees

Service Company : VAUGHN ENERGY SERVICES

DRILLOG GYRO SURVEY CALCULATIONS
Filename: PRESBY #1-H.ut
Minimum Curvature Method
Report Date/Time: 7/9/2008 / 08:40

Vaughn Energy Services
Fort Worth, TX
1-817-741-3610

Measured Depth FT	Incl Angle Deg	Drift Direction Deg	TVD FT	+N/-S FT	+E/-W FT	Vertical Section FT	Closure Distance FT	Closure Direction Deg	Dogleg Severity Deg/100
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	****
200.00	0.12	359.41	200.00	0.21	0.00	0.21	0.21	359.41	0.06
400.00	0.49	190.80	400.00	-0.42	-0.17	-0.42	0.45	201.29	0.30
600.00	0.10	144.72	599.99	-1.41	-0.23	-1.41	1.43	189.14	0.21
800.00	0.45	333.76	799.99	-0.84	-0.47	-0.84	0.97	209.42	0.27
1000.00	0.05	206.76	999.99	-0.22	-0.87	-0.22	0.89	255.71	0.24
1200.00	0.28	215.23	1199.99	-0.70	-1.19	-0.70	1.38	239.45	0.11
1400.00	0.15	213.26	1399.99	-1.31	-1.61	-1.31	2.08	230.79	0.07
1600.00	0.08	225.31	1599.99	-1.62	-1.84	-1.62	2.46	228.69	0.04
1800.00	0.16	230.91	1799.99	-1.89	-2.16	-1.89	2.87	228.74	0.04
2000.00	0.07	236.70	1999.99	-2.14	-2.48	-2.14	3.27	229.24	0.04
2200.00	0.56	238.68	2199.98	-2.72	-3.43	-2.72	4.38	231.58	0.25
2400.00	1.29	258.72	2399.96	-3.67	-6.48	-3.67	7.45	240.46	0.39
2600.00	1.40	279.96	2599.90	-3.69	-11.09	-3.69	11.69	251.59	0.25
2800.00	1.27	306.42	2799.85	-1.96	-15.28	-1.96	15.40	262.69	0.31
3000.00	2.72	329.86	2999.73	3.46	-19.44	3.46	19.74	280.10	0.82
3200.00	1.53	319.94	3199.59	9.62	-23.54	9.62	25.43	292.22	0.62
3400.00	1.23	349.94	3399.53	13.77	-25.64	13.77	29.10	298.24	0.39
3600.00	1.15	275.53	3599.50	16.07	-28.01	16.07	32.29	299.84	0.72
3800.00	1.52	268.48	3799.44	16.19	-32.66	16.19	36.45	296.37	0.20

Measured Depth FT	Incl Angle Deg	Drift Direction Deg	TVD FT	+N/-S FT	+E/-W FT	Vertical Section FT	Closure Distance FT	Closure Direction Deg	Dogleg Severity Deg/100
4000.00	1.11	247.42	3999.39	15.38	-37.11	15.38	40.17	292.51	0.31
4200.00	1.51	238.61	4199.34	13.26	-41.15	13.26	43.23	287.85	0.22
4400.00	1.10	260.36	4399.29	11.56	-45.29	11.56	46.74	284.32	0.32
4600.00	1.79	221.52	4599.23	8.91	-49.24	8.91	50.04	280.25	0.58
4800.00	2.45	220.07	4799.09	3.30	-54.06	3.30	54.16	273.49	0.33
5000.00	0.24	218.12	4999.02	-0.31	-57.08	-0.31	57.08	269.68	1.11
5200.00	0.34	156.52	5199.02	-1.20	-57.11	-1.20	57.12	268.80	0.16
5400.00	1.90	97.42	5398.98	-2.17	-53.59	-2.17	53.63	267.68	0.87
5600.00	2.54	72.31	5598.83	-1.25	-46.07	-1.25	46.09	268.45	0.58
5800.00	3.44	141.70	5798.62	-4.61	-38.13	-4.61	38.41	263.11	1.74
6000.00	1.90	138.49	5998.39	-11.79	-32.22	-11.79	34.31	249.89	0.77
6200.00	1.17	75.62	6198.33	-13.77	-28.04	-13.77	31.24	243.84	0.86
6400.00	1.85	63.88	6398.26	-11.84	-23.17	-11.84	26.02	242.92	0.38
6600.00	2.10	56.27	6598.14	-8.39	-17.22	-8.39	19.15	244.03	0.18
6800.00	0.84	58.21	6798.07	-5.58	-12.93	-5.58	14.08	246.64	0.63
7000.00	0.21	319.40	6998.07	-4.53	-11.92	-4.53	12.75	249.21	0.45
7200.00	0.83	331.36	7198.06	-2.97	-12.86	-2.97	13.20	257.01	0.31
7400.00	0.81	324.39	7398.04	-0.55	-14.38	-0.55	14.39	267.82	0.05
7600.00	1.99	300.37	7597.97	2.35	-18.19	2.35	18.34	277.37	0.65
7800.00	2.10	286.18	7797.85	5.13	-24.72	5.13	25.25	281.73	0.26
8000.00	0.32	275.83	7997.80	6.21	-28.80	6.21	29.47	282.17	0.90
8200.00	1.35	268.65	8197.77	6.22	-31.72	6.22	32.32	281.09	0.52
8400.00	1.73	253.13	8397.70	5.28	-36.97	5.28	37.35	278.13	0.28
8600.00	0.92	232.58	8597.64	3.43	-41.14	3.43	41.28	274.77	0.47
8800.00	1.12	237.49	8797.61	1.41	-44.05	1.41	44.07	271.84	0.11
9000.00	1.21	266.68	8997.57	0.24	-47.80	0.24	47.80	270.29	0.30
9200.00	0.72	31.20	9197.56	1.20	-49.26	1.20	49.27	271.39	0.86
9400.00	1.26	303.05	9397.54	3.47	-50.45	3.47	50.57	273.94	0.72
9600.00	1.85	263.86	9597.47	4.33	-55.51	4.33	55.68	274.46	0.59
9645.00	1.81	259.64	9642.44	4.12	-56.93	4.12	57.08	274.14	0.31

VES

VAUGHN ENERGY SERVICES

State of Texas
County Tarrant

I Dale Jakeway certify that I am employed by Vaughn Energy Services. That I did on the day(s) of 2/9/08 through 02/09/08 conduct or supervise the taking of a rate gyro survey from a depth of 0 feet to a depth of 9645 feet; that the data is true, correct, complete and within the limitations of the tool as set forth by Vaughn Energy Services, that I am authorized and qualifed to make this report; that this survey was conducted at the at the request of Endeavor for the Presby Well # 1H API # 42-217-30529 in Hill County, Texas; and that I have reviewed this report and find that it conforms to the principles and procedures as set forth by Vaughn Energy Services

Dale Jakeway
Service Technician
Vaughn Energy Services

PERMIT PLAT
OF
PRESBY # 1H
IN THE
JOHN BEACH SURVEY, ABSTRACT 51,
WILLIAM O. MERRIWETHER SURVEY, ABSTRACT 562,
M. G. HERRERRA SURVEY, ABSTRACT 363 AND THE
MATTHEW JONETT SURVEY, ABSTRACT 472
HILL COUNTY, TEXAS
532.74 ACRES
FOR ENDEAVOR ENERGY RESOURCES, L.P.

Surface Hole Location (SHL)
NAD 83 TX. SPC
Lat. = 32°12'24.051225" N
Long. = 97°04'37.882194" W
N. = 6761115.261743
E. = 2408580.005009
Elev. = 803

Point of Penetration (POP)
NAD 83 TX. SPC
Lat. = 32°12'22.681817" N
Long. = 97°04'43.474163" W
N. = 6760970.372306
E. = 2408101.458197

Bottom Hole Location (BHL)
NAD 83 TX. SPC
Lat. = 32°12'14.839513" N
Long. = 97°05'15.489391" W
N. = 6760140.825286
E. = 2405361.595893

SZURGOT & PEEDE
LAND SURVEYORS, LTD.
125 N. COVINGTON STREET
P.O. BOX 533
HILLSBORO, TEXAS 76645
Ph 254/582-3231
Fax 254/582-3234
e-mail: szurveyors@hillsboro.net

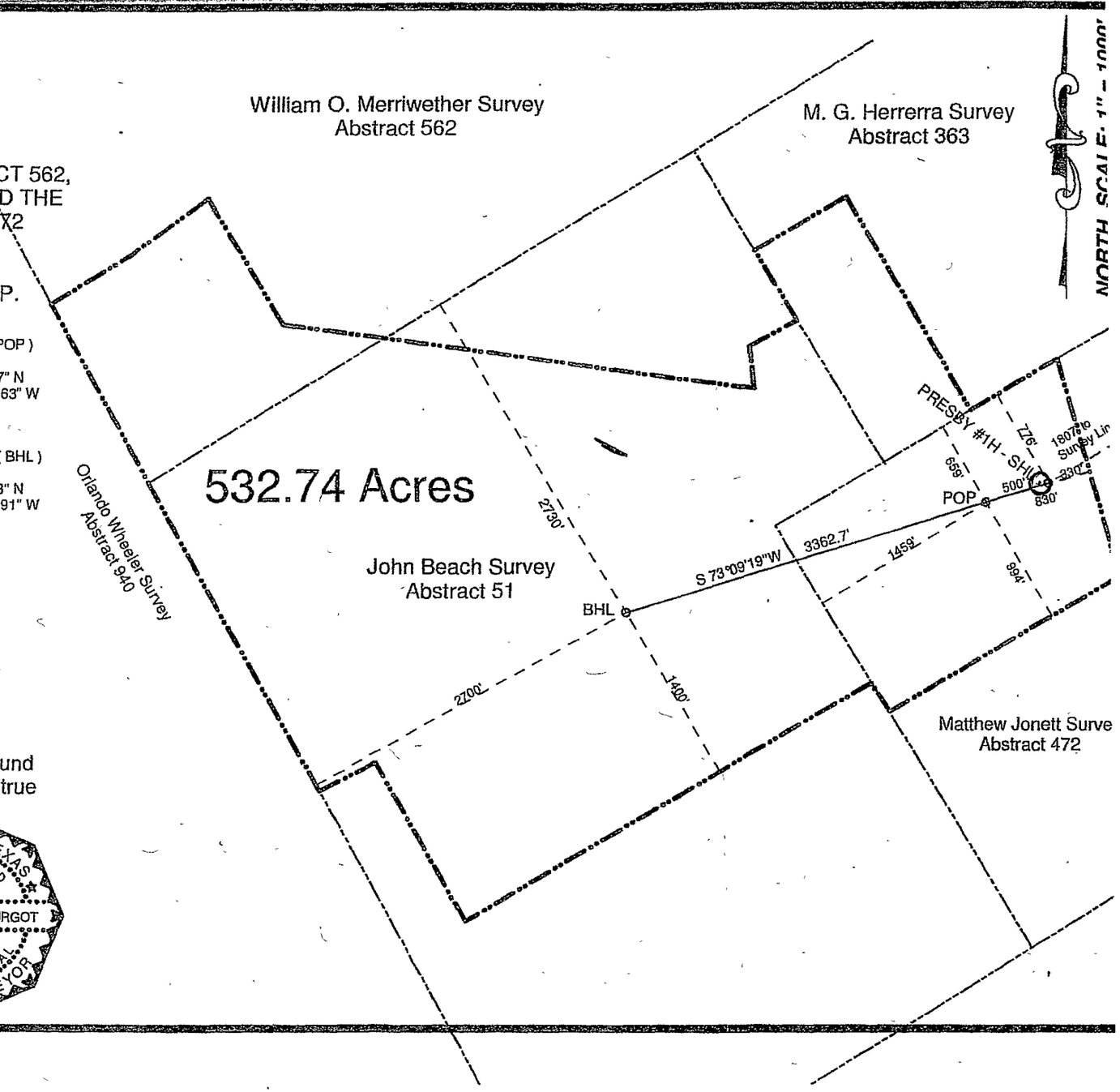
Surveyors Certificate:

This plat represents an actual survey made on the ground under my supervision on NOVEMBER 2, 2007, and is true and correct to the best of my knowledge.

STATE OF TEXAS
REGISTERED
DONALD B. SZURGOT
1780
PROFESSIONAL
LAND SURVEYOR

Donald B. Szurgot
Registered Professional Land Surveyor
No. 1780, State of Texas

J. N. 110407.1 mlh
rev. pop&shl 12/03/07 mlh



Bottom hole location 57.08' @ 274.14° of surface location.
MD: 9645'
TVD: 9642.44'
North: 4.12'
West: 56.93'

INTREPID
Directional Drilling Specialists

Railroad Commission of Texas
Oil and Gas Division
PO Box 12967
Capitol Station
Austin, TX 78711

RECEIVED
RRC OF TEXAS
MAR 04 2010
O&G
AUSTIN TX

Attention: Pam Johns

Re: Endeavor Energy Resources, L.P.
Presby #1H
Hill County, Texas
API # 42-217-30529

Enclosed, please find the original and one copy of the survey performed on the referenced well by INTREPID MWD TECH., a division of INTREPID DIRECTIONAL DRILLING SPECIALISTS. Other information required by your office is as follows:

Name & Title of Surveyor	Drainhole Number	Surveyed Depths	Dates Performed	Type of Survey
Sim Taylor MWD Engineer	#1 Sidetrack #1 Sidetrack #2	8600' – 9501' 8600' – 9913' 8600' – 11972'	12-23-07, 06-08-08	MWD/D&I WITH GAMMA

A certified plat on which the bottom hole is oriented both to the surface location and to the lease lines (or unit lines in case of pooling) is attached to the survey report. If any other information is required, please contact the undersigned at the letterhead address and phone number.

Sincerely,

J Ward

Well Planner
Jeremy Ward

Enclosures: 2

There are 3 sets of surveys in this letter because their were two sidetracks on this well

1601 Idlewilde Dr. Midland, TX. 79703 (432) 699-4304

INTREPID
Directional Drilling Specialists

State of Texas
County of Hill

I, Sim Taylor, certify that; I am employed by INTREPID DIRECTIONAL DRILLING SPECIALISTs, Ltd.; that I did on the days of 12/23/07 through 06/08/08 conduct or supervise the taking of MWD surveys from a depth of 8600 feet to a depth of 9501 feet, a depth of 8600 feet to a depth of 9913 feet, and a depth of 8600 feet to a depth of 11972 feet; that the data is true, correct, complete and within the limitations of the tool as set forth by INTREPID MWD, a division of INTREPID DIRECTIONAL DRILLING, Ltd.; that I am authorized and qualified to make this report; that this survey was conducted at the request of Endeavor Energy Resources L.P. in Hill County, Texas API Well # 42-217-30529; and that I have reviewed this report and find that it conforms to the principles and procedures as set forth by INTREPID MWD. a division of INTREPID DIRECTIONAL DRILLING SPECIALISTS, Ltd.

Sim Taylor,
MWD Engineer

1601 Idlewilde Dr. Midland, TX. 79703 (432) 699-4304

BHL sidetrack #2 is @ 3040.61 ft @ 252.93°

BHL sidetrack #1 is @ 919.34 ft @ 253.62°

BHL #1 is @ 488.35 ft @ 256.01°

PERMIT PLAT
OF
PRESBY # 1H
IN THE
JOHN BEACH SURVEY, ABSTRACT 51,
WILLIAM O. MERRIWETHER SURVEY, ABSTRACT 562,
M. G. HERRERRA SURVEY, ABSTRACT 363 AND THE
MATTHEW JONETT SURVEY, ABSTRACT 472
HILL COUNTY, TEXAS
532.74 ACRES
FOR ENDEAVOR ENERGY RESOURCES, L.P.

Surface Hole Location (SHL)
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Elev. = 803

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E. = 2408101.458197

Bottom Hole Location (BHL)
NAD 83 TX. SPC
Lat. = 32°12'14.839513" N
Long. = 97°05'15.489391" W
N. = 6760140.825286
E. = 2405361.595893

SZURGOT & PEEDE LAND SURVEYORS, LTD.
125 N. COVINGTON STREET
P.O. BOX 533
HILLSBORO, TEXAS 76645
Ph 254/582-3231
Fax 254/582-3234
e-mail: szurveyors@hillsboro.net

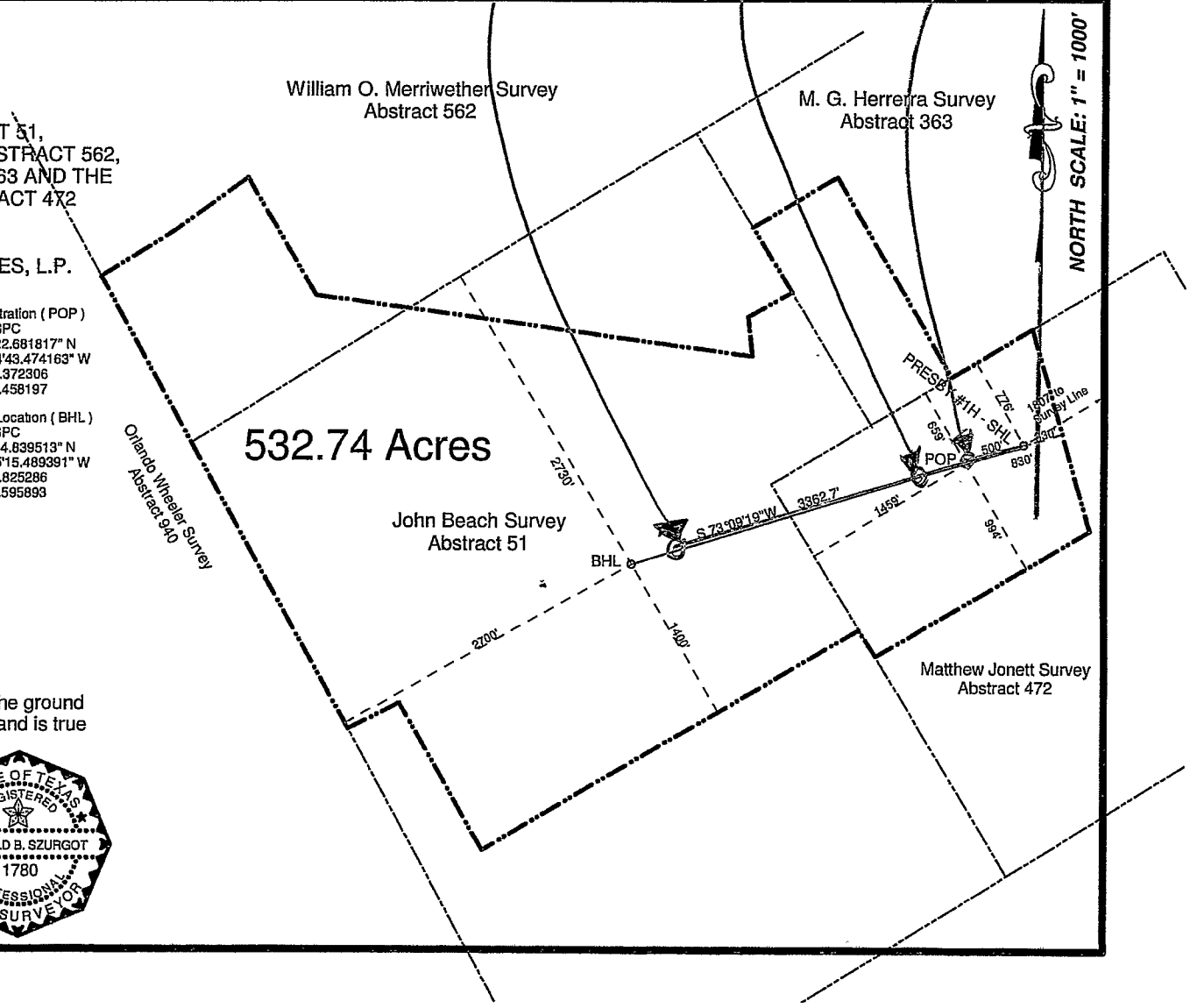
Surveyors Certificate:

This plat represents an actual survey made on the ground under my supervision on NOVEMBER 2, 2007, and is true and correct to the best of my knowledge.

Donald B. Szurgot
Registered Professional Land Surveyor
No. 1780, State of Texas

STATE OF TEXAS REGISTERED DONALD B. SZURGOT 1780 PROFESSIONAL LAND SURVEYOR

J. N. 110407.1 mlh
rev. pop&shl 12/03/07 mlh



INTREPID
Directional Drilling Specialists

Survey Report

Report Date:	February 25, 2010	Survey / DLS Computation Method:	Minimum Curvature / Lubinski
Client:	Endeavor Energy Resources, LP	Vertical Section Azimuth:	253.155°
Field:	Hill County, TX NAD 83	Vertical Section Origin:	N 0.000 ft, E 0.000 ft
Structure / Slot:	Presby #1H / Presby #1H	TVD Reference Datum:	RKB
Well:	Presby #1H	TVD Reference Elevation:	0.0 ft relative to
Borehole:	Presby #1H	Sea Bed / Ground Level Elevation:	0.000 ft relative to
UWI/API#:		Magnetic Declination:	4 579°
Survey Name / Date:	Presby #1H_surveys2 / February 14, 2008	Total Field Strength:	49563 303 nT
Tort / AHD / DDI / ERD ratio:	112 890° / 617.07 ft / 4.852 / 0.066	Magnetic Dip:	61 284°
Grid Coordinate System:	NAD83 Texas State Planes, North Central Zone, US Feet	Declination Date:	February 14, 2008
Location Lat/Long:	N 32 12 24.051, W 97 4 37 882	Magnetic Declination Model:	IGRF 2010
Location Grid N/E Y/X:	N 6761115 262 ftUS, E 2408580.005 ftUS	North Reference:	Grid North
Grid Convergence Angle:	+0 77599290°	Total Corr Mag North -> Grid North:	+3 803°
Grid Scale Factor:	0 99998049	Local Coordinates Referenced To:	Well Head

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
Tie-In	8600.00	0.92	232.58	8597.65	38.31	3.44	-41.07	41.22	274.79	0.46	189.20M
	8643.00	1.10	189 20	8640 64	38.82	2 82	-41.41	41.51	273 90	1.78	211.80M
	8675.00	0.90	211 80	8672.63	39.14	2.31	-41.60	41.66	273 18	1.37	237.80M
	8707.00	1.20	237.80	8704.63	39.65	1.92	-42.01	42.05	272 61	1 74	258.60M
	8740.00	2.00	258.60	8737.62	40.56	1.62	-42.87	42.90	272.16	2 96	264 90M
	8771.00	4.40	264 90	8768.57	42.26	1.41	-44.58	44 61	271.81	7.81	265 80M
	8804.00	8.80	265.80	8801.34	45.97	1.11	-48 36	48.38	271.31	13.34	0.55L
	8835.00	13.80	265 60	8831.73	51.90	0.65	-54.42	54 42	270.68	16.13	1 90L
	8867.00	17.40	265 20	8862.55	60.30	-0.04	-62.99	62.99	269.96	11 25	2.92R
	8899.00	20.10	265 60	8892.84	70.35	-0.87	-73.25	73.25	269 32	8.45	8.84L
	8931.00	22.30	264.70	8922 68	81.67	-1 85	-84.78	84.80	268.75	6.95	19.81L
	8962.00	24.50	262 80	8951.13	93.77	-3.20	-97 01	97.06	268.11	7.50	17.84L
	8994.00	26.90	261.10	8979.96	107 49	-5.15	-110.75	110 87	267.34	7.85	32.11L
	9025 00	29.80	257.50	9007.24	122.12	-7.90	-125 20	125.45	266.39	10 86	29.37L
	9057.00	32.40	254.80	9034.64	138.62	-11 87	-141.24	141.74	265.20	9.22	8.17L
	9089.00	36 10	253.90	9061.09	156.62	-16.74	-158.58	159.46	263 98	11.67	0.90L
	9121.00	40.20	253.80	9086.24	176.38	-22.23	-177 56	178.95	262.86	12.81	1 16L
	9152 00	43.60	253.70	9109 32	197.08	-28.03	-197.43	199.41	261.92	10.97	12.50R
	9184.00	46.90	254.70	9131 84	219.80	-34 21	-219.30	221.95	261.13	10.55	5.04L
	9216.00	48 60	254.50	9153.36	243.48	-40 50	-242.13	245.50	260.50	5.33	HS
	9249.00	50.20	254.50	9174.83	268.53	-47.19	-266.28	270.43	259 95	4.85	1.82L
	9278.00	52.70	254 40	9192.90	291.20	-53.27	-288.13	293 01	259.52	8.62	20.14L
	9309.00	55.40	253.20	9211 10	316.29	-60.28	-312.22	317.99	259.07	9 26	8.59L
	9341.00	58.80	252.60	9228.48	343.15	-68.18	-337.90	344.71	258.59	10.74	33 75L
	9373.00	60.50	251.30	9244 65	370.76	-76 74	-364.15	372.15	258.10	6.36	24.92L
	9405 00	63.00	250.00	9259.79	398.92	-86.08	-390 74	400.11	257.58	8.59	16.11L
	9436.00	66 50	248.90	9273 02	426.89	-95.93	-416 99	427.88	257.04	11.74	3 08L
	9469.00	70.00	248 70	9285.24	457.45	-107.01	-445.56	458 23	256.50	10 62	HS
	9501.00	73 50	248.70	9295.26	487.75	-118.05	-473.87	488.35	256.01	10.94	---

Survey Report

INTREPID Directional Drilling Specialists

Report Date:	February 25, 2010	Survey / DLS Computation Method:	Minimum Curvature / Lubinski
Client:	Endeavor Energy Resources, LP	Vertical Section Azimuth:	253.155°
Field:	Hill County, TX NAD 83	Vertical Section Origin:	N 0 000 ft, E 0.000 ft
Structure / Slot:	Presby #1H / Presby #1H	TVD Reference Datum:	RKB
Well:	Presby #1H	TVD Reference Elevation:	0.0 ft relative to
Borehole:	Presby #1H	Sea Bed / Ground Level Elevation:	0.000 ft relative to
UWI/API#:		Magnetic Declination:	4.573°
Survey Name / Date:	Presby #1H_sidetrack / March 4, 2008	Total Field Strength:	49557 634 nT
Tort / AHD / DDI / ERD ratio:	139.279° / 1050.59 ft / 5 193 / 0.113	Magnetic Dip:	61.282°
Grid Coordinate System:	NAD83 Texas State Planes, North Central Zone, US Feet	Declination Date:	March 04, 2008
Location Lat/Long:	N 32 12 24.051, W 97 4 37 882	Magnetic Declination Model:	IGRF 2010
Location Grid N/E Y/X:	N 6761115 262 ftUS, E 2408580.005 ftUS	North Reference:	Gnd North
Grid Convergence Angle:	+0.77599290°	Total Corr Mag North -> Grid North:	+3.797°
Grid Scale Factor:	0.99998049	Local Coordinates Referenced To:	Well Head

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
Tie-In	8600.00	0.92	232.58	8597.65	38.31	3.44	-41.07	41.22	274 79	0.46	190.80M
	8638.00	1 20	190.80	8635.64	38.78	2.87	-41.39	41.49	273 96	2.10	221.30M
	8669.00	1 20	221.30	8666.63	39.21	2 30	-41.67	41.73	273.16	2.04	243.40M
	8702.00	2.20	243.40	8699.62	40.13	1.76	-42.46	42.50	272.37	3 57	258.60M
	8734.00	4.70	258.60	8731.56	42.04	1.23	-44 29	44.31	271 58	8.25	261.40M
	8766.00	8.20	261 40	8763 35	45.60	0.63	-47 84	47.84	270.75	10.98	3 46R
	8798 00	11.50	262.40	8794.88	51 01	-0.14	-53.26	53.26	269.85	10.33	0.83R
	8832.00	15 10	262.60	8827.96	58.73	-1.16	-61.01	61.02	268.91	10.59	4 81L
	8863 00	18.50	261.70	8857.63	67 58	-2 39	-69.88	69.93	268.04	11.00	7.16L
	8894.00	22.10	260.50	8886.70	78 23	-4.06	-80 51	80.61	267 11	11.69	1.71R
	8926.00	26.60	260.80	8915.85	91.31	-6 20	-93.52	93 73	266.21	14.07	0.65R
	8958.00	31.20	260.90	8943.85	106.63	-8.66	-108.79	109.13	265.45	14.38	3.22L
	8991.00	34 20	260.60	8971.62	124.30	-11.53	-126.38	126.90	264.79	9.10	32.18L
	9023.00	35.50	259.20	8997.88	142.46	-14 74	-144.38	145 13	264.17	4 77	14.00L
	9054.00	37.20	258.50	9022.85	160.74	-18.29	-162.41	163.43	263 57	5 64	30.22L
	9086.00	38.60	257 20	9048.10	180.33	-22.43	-181.62	183.00	262.96	5.04	23.01L
	9118.00	40.60	255 90	9072.75	200.69	-27.18	-201.46	203.28	262.32	6.76	1.70R
	9150 00	42.90	256.00	9096 63	221.97	-32.35	-222.13	224.47	261 71	7.19	9 39R
	9183 00	44.60	256 40	9120.46	244.76	-37 79	-244.29	247 19	261.21	5.22	2.58L
	9215.00	46 20	256.30	9142 93	267.50	-43.17	-266 43	269.90	260.80	5.00	HS
	9248 00	48 00	256.30	9165 39	291.64	-48 90	-289.91	294 01	260.43	5.45	1.77L
	9280.00	50.50	256.20	9186 28	315.85	-54.66	-313.46	318.19	260 11	7.82	2 72R
	9312.00	53.90	256 40	9205.89	341.09	-60 64	-338.02	343.42	259.83	10.64	1.42R
	9344 00	57.30	256 50	9223.97	367.45	-66.83	-363.68	369.77	259.59	10.63	5.86R
	9376 00	60.70	256 90	9240 45	394.82	-73.14	-390.37	397.17	259.39	10.68	2 42R
	9407.00	65 00	257.10	9254 59	422.33	-79.34	-417 25	424.72	259 23	13.88	10.87L
	9439.00	69.90	256 10	9266.86	451.82	-86.19	-445.98	454.24	259.06	15.58	16.06L
	9469 00	74 60	254.70	9276 00	480.37	-93.40	-473 62	482.74	258.84	16.28	26.76L
	9501.00	78.30	252 80	9283.50	511.47	-102.10	-503.48	513.73	258 54	12.92	33.12L
	9533.00	81.80	250.50	9289.03	542 97	-112 03	-533.39	545.03	258.14	13.03	28.28L
	9565 00	85.70	248 40	9292 51	574.70	-123 19	-563.17	576.48	257.66	13.82	22.65L
	9596.00	90 50	246.40	9293 54	605.52	-135.09	-591 76	606.99	257 14	16.77	7.12L
	9628.00	92.90	246 10	9292.59	637.27	-147.98	-621.04	638.42	256.60	7.56	44.95R
	9660 00	93.20	246.40	9290 89	668.99	-160.85	-650.28	669.88	256.11	1.32	21.76R
	9691.00	93.70	246 60	9289 02	699.73	-173.18	-678.66	700.41	255.68	1.74	8.11R
	9722 00	94.40	246.70	9286 83	730.45	-185.44	-707.05	730.97	255.30	2.28	HS
	9755.00	95.50	246.70	9283.98	763.12	-198 44	-737.25	763 49	254.93	3.33	121.05R
	9786.00	95.20	247.20	9281.09	793.80	-210.53	-765.65	794.06	254.63	1.87	8.09L
	9818.00	95.90	247 10	9278.00	825 48	-222.90	-795.00	825 65	254.34	2.21	28.88R

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
	9850 00	96 80	247.60	9274.46	857.12	-235 14	-824 35	857 23	254 08	3.21	52.90L
	9881.00	97.10	247.20	9270.71	887.74	-246.97	-852.76	887.80	253.85	1 61	26 35R
	9913.00	97.70	247 50	9266.59	919.31	-259.19	-882.04	919.34	253 62	2 09	---

INTREPID
Directional Drilling Specialists

Survey Report

Report Date:	February 25, 2010	Survey / DLS Computation Method:	Minimum Curvature / Lubinski
Client:	Endeavor Energy Resources, LP	Vertical Section Azimuth:	253.155°
Field:	Hill County, TX NAD 83	Vertical Section Origin:	N 0 000 ft, E 0 000 ft
Structure / Slot:	Presby #1H / Presby #1H	TVD Reference Datum:	RKB
Well:	Presby #1H	TVD Reference Elevation:	0.0 ft relative to
Borehole:	Presby #1H	Sea Bed / Ground Level Elevation:	0 000 ft relative to
UWI/API#:		Magnetic Declination:	4.562°
Survey Name / Date:	Presby #1H_sidetrack2 / April 5, 2008	Total Field Strength:	49548.386 nT
Tort / AHD / DDI / ERD ratio:	179.054° / 3169 18 ft / 5 866 / 0.343	Magnetic Dip:	61.279°
Grid Coordinate System:	NAD83 Texas State Planes, North Central Zone, US Feet	Declination Date:	April 04, 2008
Location Lat/Long:	N 32 12 24 051, W 97 4 37.882	Magnetic Declination Model:	IGRF 2010
Location Grid N/E Y/X:	N 6761115.262 ftUS, E 2408580.005 ftUS	North Reference:	Grid North
Grid Convergence Angle:	+0.77599290°	Total Corr Mag North -> Grid North:	+3 786°
Grid Scale Factor:	0 99998049	Local Coordinates Referenced To:	Well Head

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
Tie-In	8600.00	0.92	232.58	8597.65	38.31	3.44	-41.07	41.22	274.79	0.46	248 20M
	8641 00	5 00	248.20	8638.58	40.40	2.58	-42.99	43 07	273.43	10.05	34.87R
	8673.00	6 50	257.00	8670 42	43.60	1 65	-46 05	46.08	272.06	5.42	14.06R
	8705 00	9.30	261.30	8702.11	47.97	0 85	-50.38	50.38	270.97	8.94	5.18L
	8737 00	11.50	260.30	8733.59	53.69	-0.07	-56.08	56.08	269.92	6.90	4.98L
	8768.00	14.00	259.40	8763.82	60.49	-1.29	-62.81	62.82	268.83	8.09	8.43L
	8800.00	17 20	257.80	8794.64	69 05	-3.00	-71.24	71.30	267.59	10.09	6.58L
	8831 00	21.30	256.50	8823.90	79.25	-5.28	-81 20	81.37	266.28	13.30	8.19L
	8863 00	25.50	255.10	8853.26	91.94	-8.41	-93.51	93.89	264.86	13.24	4.29L
	8891.00	28 70	254.60	8878.18	104 69	-11.75	-105.82	106.47	263.67	11.46	1.04R
	8921.00	31.60	254.70	8904 12	119.75	-15 73	-120.35	121.38	262.55	9.67	2 31R
	8953.00	34.40	254 90	8930 96	137.17	-20 30	-137 17	138.66	261.58	8.76	4.86R
	8985.00	36.50	255 20	8957.02	155.72	-25.09	-155.10	157.12	260.81	6.58	9.69L
	9017 00	38.70	254.60	8982.37	175.23	-30.18	-173.95	176.55	260.16	6.97	16.38L
	9049 00	40 70	253.70	9006 99	195.67	-35.76	-193 61	196.89	259.53	6 50	7.52L
	9081 00	43.30	253.20	9030 77	217.08	-41 86	-214 13	218.19	258.94	8.19	10.58L
	9113.00	46 00	252.50	9053.54	239 56	-48.50	-235 62	240 56	258.37	8 58	12.04R
	9144.00	49.20	253 40	9074.44	262 45	-55.20	-257.50	263 35	257.90	10 54	6 02R
	9176.00	52.20	253.80	9094.70	287.21	-62.19	-281.26	288.05	257.53	9.42	32.92L
	9207.00	53 70	252.60	9113.38	311.95	-69.35	-304.94	312.72	257.19	5.74	10.71L
	9239 00	55.00	252.30	9132.03	337.95	-77.19	-329.73	338.64	256.82	4.13	16.81L
	9272.00	56.10	251.90	9150.70	365.16	-85.55	-355.63	365.77	256.47	3.48	17.97L
	9304.00	57 40	251.40	9168.24	391.91	-93.98	-381.02	392.44	256.14	4.27	6.93R
	9336 00	61.00	251 90	9184 63	419 38	-102.63	-407 11	419.85	255 85	11.33	6.17L
	9367.00	65.20	251 40	9198 65	447.01	-111.33	-433.34	447 42	255.59	13.62	18.87L
	9399.00	69.60	249.80	9210.94	476 52	-121 15	-461 20	476.84	255.28	14.50	18.18R
	9430 00	74.00	251 30	9220.62	505.93	-130 95	-488.96	506.19	255 01	14.92	27.95R
	9462.00	76 20	252.50	9228.85	536.84	-140.55	-518.35	537.07	254.83	7.77	33.19L
	9494 00	78.30	251.10	9235.91	568.04	-150.30	-548.00	568.24	254 66	7.83	14.54L
	9527.00	80 20	250.60	9242.07	600.43	-160.94	-578.62	600.59	254.46	5.95	1.90L
	9558.00	83.20	250 50	9246 54	631.07	-171 15	-607.55	631.19	254.27	9.68	3.27L
	9590.00	86.70	250.30	9249 36	662.91	-181 84	-637.57	662.99	254.08	10.96	7.60R
	9622.00	89.70	250 70	9250.37	694.85	-192.52	-667 72	694.92	253.92	9.46	71.57L
	9686.00	90.00	249 80	9250.53	758 77	-214.14	-727 95	758.79	253.61	1.48	59.04R
	9749.00	90.30	250.30	9250.37	821 68	-235.64	-787.17	821 68	253.34	0 93	82.40R
	9813.00	90.50	251.80	9249.92	885 63	-256.42	-847.70	885.63	253.17	2 36	39.79R
	9877.00	91.70	252.80	9248 69	949.61	-275 87	-908.65	949.61	253.11	2.44	69 73L
	9888.00	92.40	250 90	9248 30	960.60	-279 30	-919.10	960.60	253.10	18 40	8.73R
	9920.00	93.70	251.10	9246.60	992 53	-289.70	-949.31	992.53	253.03	4.11	65.13R

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
	9952.00	94 30	252.40	9244.36	1024.44	-299.70	-979.63	1024 45	252.99	4.47	99.47L
	9984.00	94.20	251.80	9241.99	1056 35	-309 51	-1010.00	1056.35	252.96	1.90	44.91L
	10015.00	94 50	251.50	9239.64	1087.25	-319 24	-1039.33	1087.26	252.93	1.37	111.84L
	10047.00	94 30	251.00	9237.19	1119.14	-329.49	-1069.55	1119.15	252.88	1.68	HS
	10078 00	94.50	251.00	9234.81	1150.02	-339 56	-1098.77	1150.04	252.83	0.65	71.49L
	10110.00	94.70	250 40	9232 24	1181.89	-350.10	-1128 88	1181.92	252 77	1.97	9.42R
	10142.00	95 30	250.50	9229.45	1213.73	-360 77	-1158.92	1213.77	252.71	1.90	81.80R
	10174.00	95.40	251 20	9226 47	1245.57	-371.22	-1189.01	1245 61	252 66	2.20	56.17R
	10205.00	95 60	251 50	9223.50	1276.41	-381.08	-1218 25	1276 46	252.63	1.16	44.86R
	10237.00	95.70	251.60	9220.35	1308 24	-391 16	-1248.46	1308.30	252.60	0.44	111.87R
	10269.00	95.50	252.10	9217.23	1340.08	-401.08	-1278 72	1340.15	252.59	1.68	153.53R
	10301.00	95.30	252.20	9214.21	1371.93	-410 85	-1309.05	1372.00	252.58	0.70	135 12R
	10332.00	95.20	252 30	9211.38	1402.80	-420.26	-1338 45	1402.87	252.57	0.46	127.94R
	10364.00	94.50	253.20	9208.67	1434 68	-429.72	-1368.90	1434.76	252.57	3.56	135.07R
	10396.00	94.20	253 50	9206 24	1466.59	-438.86	-1399.47	1466.66	252.59	1.32	44.90R
	10427.00	94.60	253.90	9203.87	1497.50	-447.53	-1429 13	1497.57	252.61	1.82	90.00R
	10459.00	94.60	254 30	9201.30	1529 39	-456.27	-1459 81	1529.45	252.64	1.25	150 67R
	10491.00	93.00	255 20	9199.18	1561.31	-464.67	-1490 61	1561.36	252.69	5.73	172.41L
	10522.00	91.50	255.00	9197.96	1592.26	-472.63	-1520 55	1592.31	252.73	4.88	108.44L
	10554.00	91.40	254.70	9197.15	1624.24	-480.99	-1551.42	1624.28	252.77	0.99	33 68L
	10586.00	91.70	254.50	9196.29	1656.22	-489.49	-1582.26	1656 25	252.81	1.13	102 52R
	10615.00	91.50	255.40	9195.48	1685.19	-497.02	-1610.26	1685.22	252.85	3.18	171.47R
	10647 00	89.50	255 70	9195 20	1717.16	-505 00	-1641.24	1717.18	252 90	6.32	146.32L
	10679 00	88 30	254 90	9195.81	1749.13	-513 12	-1672.19	1749 14	252.94	4.51	108.45R
	10711.00	88 20	255.20	9196.79	1781.10	-521.37	-1703.09	1781 11	252.98	0.99	90.00L
	10742.00	88.20	254.70	9197.76	1812.07	-529.42	-1733.01	1812.08	253.01	1.61	90.00R
	10774 00	88 20	255 10	9198.77	1844.04	-537 75	-1763.89	1844 04	253 05	1.25	HS
	10806.00	88.40	255.10	9199.72	1876 01	-545.97	-1794.80	1876 01	253.08	0.63	90.00R
	10837 00	88.40	255 20	9200.58	1906.98	-553 91	-1824.76	1906.98	253 11	0.32	45.00L
	10869.00	88 70	254.90	9201.39	1938.95	-562 17	-1855.66	1938.95	253 15	1.33	63.44L
	10898.00	89.10	254.10	9201.95	1967 93	-569.92	-1883 60	1967.93	253.17	3.08	135.01R
	10930.00	88 70	254.50	9202.56	1999.92	-578.57	-1914.40	1999.92	253.18	1.77	45.00L
	10962 00	89.30	253.90	9203.12	2031.91	-587.28	-1945.19	2031.91	253.20	2.65	45.00L
	10993.00	89 50	253.70	9203.45	2062.91	-595.93	-1974 96	2062.91	253.21	0.91	HS
	11025.00	90.20	253 70	9203.53	2094.91	-604.91	-2005 67	2094.91	253.22	2.19	32.00R
	11057.00	91.00	254.20	9203.20	2126.90	-613.76	-2036.42	2126.90	253.23	2.95	141.34L
	11089.00	90.50	253.80	9202.78	2158.89	-622.58	-2067.18	2158.90	253.24	2.00	LS
	11120.00	89 80	253.80	9202.70	2189.89	-631.23	-2096.95	2189.89	253.25	2 26	168.69L
	11152.00	89 30	253.70	9202.95	2221.89	-640.18	-2127.67	2221.89	253.25	1 59	36.87L
	11184.00	89.70	253 40	9203 23	2253.89	-649 24	-2158.36	2253.89	253.26	1.56	75.96L
	11215.00	89 80	253.00	9203.36	2284 89	-658.20	-2188.03	2284.89	253.26	1.33	135.00L
	11247.00	89.50	252 70	9203.56	2316 89	-667.64	-2218 61	2316.89	253.25	1.33	153.44R
	11279.00	88.70	253.10	9204 06	2348.88	-677.05	-2249 19	2348.88	253.25	2.80	129.82L
	11310.00	88.20	252 50	9204.90	2379.87	-686.21	-2278.79	2379.87	253.24	2.52	11 31L
	11342.00	88.70	252.40	9205.76	2411.85	-695.86	-2309.29	2411.86	253.23	1.59	18.43L
	11374 00	89.00	252.30	9206.41	2443.84	-705.56	-2339.78	2443.85	253.22	0.99	20 56R
	11406 00	89.80	252.60	9206.74	2475.84	-715.21	-2370.29	2475.84	253.21	2.67	153.43L
	11439.00	89 60	252.50	9206.91	2508.84	-725.10	-2401.77	2508.84	253.20	0.68	138.82R
	11471.00	88.80	253.20	9207 36	2540.83	-734.54	-2432 34	2540.83	253.20	3.32	110.57L
	11503.00	88 50	252.40	9208.11	2572.82	-744.00	-2462.90	2572.82	253.19	2 67	HS
	11534.00	88.90	252 40	9208 82	2603.81	-753 37	-2492.45	2603.81	253.18	1 29	135.01R
	11566.00	88.70	252.60	9209.49	2635 80	-762.99	-2522 96	2635.80	253.17	0.88	90.00L
	11598.00	88.70	251.80	9210 21	2667.79	-772.77	-2553 42	2667.79	253.16	2.50	131.21R
	11630.00	88.00	252 60	9211.14	2699.77	-782.55	-2583.87	2699.77	253.15	3.32	143.16L
	11663.00	87.60	252.30	9212.40	2732 75	-792 49	-2615 31	2732.75	253.14	1 51	14.03R
	11694.00	88.00	252 40	9213 59	2763.72	-801 88	-2644.83	2763.72	253.13	1.33	108.46L

Comments	Measured Depth (ft)	Inclination (deg)	Azimuth (deg)	TVD (ft)	Vertical Section (ft)	NS (ft)	EW (ft)	Closure (ft)	Closure Azimuth (deg)	DLS (deg/100 ft)	Mag / Grav Tool Face (deg)
	11726 00	87.70	251.50	9214.79	2795.69	-811.79	-2675.24	2795.69	253 12	2.96	90.00L
	11758 00	87.70	250.60	9216.08	2827.64	-822.17	-2705 48	2827 64	253.10	2.81	171.88R
	11789.00	87.00	250.70	9217.51	2858.58	-832.43	-2734 69	2858.58	253.07	2 28	165.99L
	11821.00	86 60	250 60	9219.30	2890 50	-843.02	-2764 84	2890 50	253.04	1.29	143.21L
	11853.00	85.80	250.00	9221 42	2922 39	-853 78	-2794 90	2922.40	253.01	3.12	157.47R
	11885.00	84.60	250.50	9224 09	2954.24	-864.56	-2824.91	2954.25	252.98	4.06	146.48R
	11916.00	83.70	251 10	9227 25	2985.05	-874 70	-2854.03	2985.06	252.96	3.48	148.20L
	11948.00	82.90	250.60	9230.99	3016 80	-885.13	-2884 06	3016 82	252.94	2.94	161.71L
	11972.00	82.60	250.50	9234.02	3040 59	-893.05	-2906 51	3040 61	252.92	1.32	---

SECTION IX

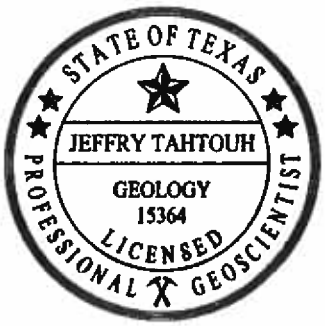
WASTE STREAM COMPATIBILITY WITH INJECTION AND CONFINING ZONES

GEOSCIENTIST'S SEAL

I, Jeffry Tahtouh, P.G., the undersigned, state: I am employed by WSP USA, and I am authorized to prepare this document. This document was prepared under my supervision and direction. The information in this document was prepared in accordance with generally accepted geosciences principles and practices.

This certification and seal apply to the following documents:

Section IX.A.4
Pages IX-3 through IX-4



Name: Jeffry Tahtouh, P.G.
Title: Senior Geologist
WSP USA Inc.
Texas Geoscience Firm 50561

Signature Jeffry Tahtouh Date Signed 12/27/2023
Licensed Professional Geologist No. 15364

IX. WASTES AND WASTE MANAGEMENT

IX.A WASTE GENERATION AND MANAGEMENT ACTIVITIES

The NTI Facility will operate as a commercial processing and treatment facility that accepts nonhazardous waste for disposal in their associated nonhazardous commercial deep disposal injection well (IW-1). The facility will receive nonhazardous industrial wastewater and nonhazardous municipal landfill leachate wastewater that is suitable for disposal into the proposed injection well. All wastewater received at the facility will be transferred into above ground temporary storage tanks where it will be comingled with other waste streams prior to disposal. All analytical data submitted to the TCEQ will be generated by a lab that the Texas Laboratory Accreditation Program (TLAP) has accredited under the National Environmental Laboratory Accreditation Conference (NELAC) standard for matrices, methods, and parameters of analysis.

IX.A.1 WASTE STREAM SUMMARY

Table IX-A provides the waste stream, source and volume to be injected into the well that is proposed to be injected into IW-1. Below is a description of the waste streams, processes generating waste streams and sources of the waste streams.

(a) WASTE STREAMS RECEIVED FOR INJECTION

The NTI Facility will receive nonhazardous industrial Class 1 and Class 2 liquid waste streams for injection. The liquid waste streams will include inorganic and organic wastes. Inorganic liquid wastes are primarily inorganic and highly fluid, with low suspended inorganic solids and low organic content. Organic liquid wastes are primarily organic and is highly fluid, with low inorganic solids content and low-to-moderate water content. The waste streams received at the facility will consists of:

- Municipal landfill leachate;
- Aqueous solutions that contain petroleum hydrocarbons;
- Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I;
- Aqueous solutions that contain halogenated organic compounds in concentrations less than 1000 mg/l
- Aqueous acid wastes;
- Aqueous organic wastes;
- Aqueous caustic wastes;
- Aqueous metallic wastes;
- Other associated wastes such as groundwater and rainfall contaminated by the above authorized wastes, spills of the above authorized wastes, and wash waters and solutions used in cleaning and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, injection zone, and well materials; and
- Wastes generated during the closure of the well and associated facilities that are compatible with the permitted wastes, injection zone and well.

(b) PROCESSES GENERATING WASTE STREAMS

Some of the processes that generate the nonhazardous industrial Class 1 and Class 2 liquid waste streams received at the NTI Facility are provided below.

- Municipal landfill
- Wastewater from oil recovery processes
- Wash water from industrial processes
- Rain waters
- Equipment washout
- Spill cleanups
- Rinse water
- Petrochemical plant process water
- Oilfield equipment manufacturers process water
- Industrial liquids
- Waters created during industrial process containing dissolved solids

(c) SOURCES OF WASTE STREAMS/ TYPE OF FACILITY

The proposed waste streams may be generated at the following sources or facilities.

- Municipal landfills generating nonhazardous leachate
- Petroleum products processing plants generating nonhazardous wastewater
- Petrochemical plants generating nonhazardous wastewater
- Industrial customers generating nonhazardous process waters from petrochemical products
- Industrial liquids from third party waste management companies that commercially manage waste streams for the petroleum, petrochemical, and industrial industries
- Oilfield equipment manufacturing companies generating nonhazardous wastewater
- Industrial and industrial waste management companies that produce rainfall and/or spillage wastes

A description of the Pre-Injection Units and flow diagram of the facility is contained in Section XII.

IX.A.2 INDIVIDUAL AND BLENDED WASTE STREAMS

The injected fluid will consist of a water-based liquid generated from the physical processing and chemical treatment of blended Class 1 and 2 nonhazardous industrial wastes described in Table IX-B. This table also gives the TCEQ waste classification (nonhazardous Classes 1 or 2) and the TCEQ form codes.

IX.A.3 WASTE STREAM CHARACTERISTICS

Since the proposed well is a new commercial facility that has yet to accept waste streams, the proposed source and volumes of the specific waste streams is unknown. However, the proposed injected waste stream is expected to have a pH range greater than or equal to 5 and less than or equal to 8. The specific gravity is expected to range from 0.90 to 1.20 at 68°F. Once specific waste streams are identified, an analysis of pH, specific gravity and viscosity will be conducted by a lab that the Texas Laboratory Accreditation Program (TLAP) has accredited under

the National Environmental Laboratory Accreditation Conference (NELAC) standard for matrices, methods, and parameters of analysis.

IX.A.4 WASTE STREAM COMPATIBILITY

The NTI Facility is a commercial, nonhazardous facility, accepting a wide range of nonhazardous waste streams. For this reason, chemical characteristics for the injection fluid can only be characterized in terms of ranges for certain parameters. The proposed waste streams accepted by the facility will contain materials with a pH range greater than or equal to 2 and less than or equal to 12.5. The waste streams will be commingled and physically processed, which is expected to produce an injectate with a pH range between 5 and 8 prior to injection. Liquids with pH between 5 and 8 are minimally corrosive to the proposed injection well materials, as described below.

(a) COMPATIBILITY WITH WELL MATERIALS

Corrosion monitoring will be completed on a quarterly basis using test coupons constructed from materials the same as, or similar to, those used in the construction of the proposed injection well (IW-1). Coupons are maintained inline to provide the continuous exposure to the waste stream at the operating pressures, temperatures (measured at the wellhead), and flow rates of the proposed injection operation.

The component of the proposed well that is in contact with the waste stream will be constructed of carbon steel. IW-1 will be constructed with other materials that have API Specification grades that are the same or equal to the corrosion resistance properties of the injection casing. Therefore, a carbon steel coupon is sufficient to represent the various casing grades proposed for the injection well.

The corrosion coupons that are continuously exposed to the waste stream will be evaluated on a quarterly basis according to the UIC guidelines, ASTM G1, and as applicable, NACE SP0775. Additionally, a casing inspection tool (multi-figure caliper) will be run periodically as required. Multi-finger caliper logs are used to identify any significant or active corrosion in the casing.

(b) COMPATIBILITY WITH FORMATION FLUID

Formation fluid data from the Injection Zone (Ellenburger Formation) is not available. During completion of the proposed injection well, a formation fluid sample will be recovered for chemical analysis by an accredited laboratory and a compatibility study will be conducted with the proposed waste stream. There are no injection wells present at the site, and the nearest injection well that utilizes the Ellenburger Formation for disposal is approximately 9.25 miles away. The proposed injected waste stream is not expected to have an adverse reaction with native formation fluids.

(c) COMPATIBILITY WITH THE CONFINING AND INJECTION ZONES

The Confining Zone is identified as the Barnett Shale, which is composed of organic-rich siliceous, calcareous, and noncalcareous mudstones. The Injection Zone is identified as the Ellenburger Formation which known to be composed primarily of dolomite (calcium magnesium carbonate) and limestone (calcium carbonate).

Formation matrix samples from the Confining and Injection Zones have not been collected at the proposed site. Both zones will be cored during the construction of IW-1, and the mineralogy of the formations will be

characterized in detail at that time. Laboratory testing of the cores will be performed to determine formation compatibility with the proposed waste stream.

(d) COMPATIBILITY WITH FLUIDS PREVIOUSLY INJECTED

An additional issue related to compatibility refers to the reaction of the waste with other wastes being injected to form a precipitate at bottom-hole conditions. This issue is addressed by means of the following procedures.

- Samples of wastes which clients wish to be considered for injection may be first sent to a commercial laboratory for testing to establish regulatory compliance, and that they are nonhazardous. Analysis is not always required, generator knowledge or a Safety Data Sheet may be accepted depending on the waste stream. When required, an additional sample will be tested in a laboratory for testing compatibility with individual wastes and composites of other wastes received on a routine basis.
- After the sample is accepted and the waste is transported to the NTI Facility in accordance with Waste Management Procedures, it will be sampled at the gate, and tested before the load is admitted. At that time, the load sample is compared to the profile visually and chemically. The load sample is tested for pH, total suspended solids, density and flammability. The values are compared to the results of the test of the sales sample and, if they do not match, the client is notified to explain to RIES laboratory personnel the reason for the discrepancy. If a satisfactory explanation is not received, the load is returned to the client for disposal elsewhere. In extreme circumstances, the load may remain on the truck while the commercial laboratory confirms the nonhazardous nature of the load. In no instance will the load be allowed inside of the NTI Facility gate or off-loaded at NTI Facility until the load is certified as nonhazardous.
- RIES will also operate a chemical neutralization system for incompatible wastes, whereby any waste shipment with extremely high or low pH can be neutralized as it is offloaded, prior to commingling with other wastes in above-ground storage tanks at NTI waste receiving and processing facility. Since individual waste shipments commonly range in pH between 8 and 11, and incompatible wastes are neutralized, the corrosive nature of the NTI injection fluid is minimal. All well and piping materials were selected based on compatibility with the injection fluid characteristics proposed by RIES.
- RIES will conduct pH testing on each batch of injection fluid prior to commencing injection, to assure compatibility with well components.

IX.A.5 CHARACTERISTIC RANGES

The characteristic ranges of the injected fluid will be within the following ranges:

- The pH range will be greater than or equal to 5 and less than or equal to 8.
- The Specific Gravity will not exceed 1.2.

IX.A.6 WASTE ANALYSIS PLANS

The waste acceptance and verification procedures to be utilized by the associated commercial processing and treatment facility to assure that only nonhazardous industrial wastes are received is described in the Waste Analysis Plan (WAP) (Appendix IX-1).

Table IX-C lists the proposed waste stream that will be sampled, its sampling location, the sampling method, the sampling frequency, and the laboratory analytical method.

IX.A.7 RESTRICTED HAZARDOUS WASTES

This section is not applicable. This application is for a nonhazardous waste injection well.

IX.A.8 NON-RESTRICTED HAZARDOUS WASTES

This section is not applicable. This application is for a nonhazardous waste injection well. None of the proposed waste stream components are prohibited from land disposal under 40 CFR 268.

IX.A.9 INJECTION WELL SUMMARY

Included with this permit application is Table IX-D for the proposed IW-1.

IX.B WASTE MANAGEMENT (HAZARDOUS WASTE INJECTION WELLS ONLY)

This section is not applicable. This application is for a nonhazardous waste injection well.

TABLES

TABLE IX-A

WASTE MANAGEMENT SUMMARY

Individual Waste Stream	Source	Maximum Volume (gallons/year)
Aqueous waste fluid streams as listed below: — Offsite sources (nonhazardous) o Municipal landfill leachate o Class 1 and Class 2 industrial aqueous fluids as listed below: ▪ Wastewater from oil recovery process ▪ Process wastewater ▪ Rinse Water ▪ Wastewater with low levels of dissolved solids ▪ Rainwater ▪ Equipment washouts ▪ Spill cleanups ▪ Petrochemical plant process water ▪ Oilfield equipment manufacturers process water ▪ Industrial liquids ▪ Waters created during industrial process containing low dissolved solids — Offsite and Onsite sources (nonhazardous) o Other associated wastes such as groundwater and rainfall contaminated by the above authorized wastes, and wash waters and solutions used in cleaning and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, injection zone and well materials. — Onsite source o Wastes generated during closure of the well and associated facilities that are compatible with the permitted wastes, injection zone, and the well.	NTI will receive wastes from the sources listed below: — Offsite sources (nonhazardous) o Municipal landfills generating nonhazardous leachate o Petroleum products processing plants generating nonhazardous wastewater in their process o Petrochemical plants generating nonhazardous wastewater in their process o Petrochemical plants generating nonhazardous wastewater in their process o Industrial customers generating nonhazardous process wasters, petrochemical products process waters and waste streams which in turn, generate nonhazardous wastewater in the process o Industrial liquids (petroleum, petrochemical products and waste stream) waste management companies o Oilfield equipment manufacturing companies generating nonhazardous wastewater in their process of manufacture (e.g. tubing and pipe manufacturing, etc) o Industrial companies and industrial waste companies that produce rainfall and/or spillage wastes. — Onsite sources (nonhazardous) o Waste generated during commingling of offsite and onsite wastes which ultimately generates aqueous injectable nonhazardous waste streams.	≤53,647,920 gallons/year

TABLE IX-B

WASTE STREAM SUMMARY

Waste No.	Waste Stream[1]	EPA Waste Codes	EPA Hazard Codes (I, C, R, E, H, T)	TCEQ Waste Classifications (1, 2, 3, or H)	Texas Waste Codes[2]
1	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	101
2	Aqueous organic wastes	N/A	N/A	1 & 2	102
3	Aqueous metallic wastes	N/A	N/A	1 & 2	103
4	Aqueous acid wastes	N/A	N/A	1 & 2	105
5	Aqueous caustic wastes	N/A	N/A	1 & 2	110
6	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	113
7	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	114
8	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	115
9	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1	116
10	Leachate aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	N/A	N/A	2	116
11	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	119
12	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	199
13	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	205
14	Concentrated aqueous solution of other organics that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	207
15	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1	219
16	Other organic liquids that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	N/A	N/A	2	219

17	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I	N/A	N/A	1 & 2	504
18	Other associated wastes compatible with the permitted waste streams	N/A	N/A	1	603

[1]: The blended non-hazardous waste consists of the following:

- Water-based injection fluid generated from physical processing and chemical treatment of commingled Class I, II, and III nonhazardous industrial wastes and nonhazardous municipal landfill leachate
- Other associated wastes such as ground water and rainfall contaminated by the above wastes, spills of the above authorized wastes, spills of the above authorized wastes, and wash waters and solutions used in cleaning and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, Injection Zone, and well materials, and;
- Non-hazardous wastes generated during well construction or closure of the well and associated facilities that are compatible with the permitted waste streams, Injection Zone, and well materials.

[2]: The appropriate Texas Waste Code will be made up of a four-digit sequence number assigned by the generator represented by "XXXX," a three-digit form code from the list above, followed by the appropriate single-digit classification. Municipal Landfill Leachate from Texas: MSW Landfills: MLFI00TX (Municipal Solid Waste Landfill – Type I), MLFIAETX (Municipal Solid Waste Landfill – Type IAE), MLFIV0TX (Municipal Solid Waste Landfill –Type IV), MLFIVAEX (Municipal Solid Waste Landfill – Type IVAE), Municipal Landfill Leachate from Out of State Landfills: MLFLOUTS

TABLE IX-C

WASTE SAMPLING & ANALYSIS SUMMARY

Waste Number (Table IX-B)	**Sampling Location**	**Sampling Method**	**Frequency**	**Parameter**	**Test Method**
1, 2, 3, 4, 5, 6, 7, 8, 9, 10,11,12,13,14,15,16, 17,18	Bulk Liquids	Coliwasa unit or open tube sampler, or tank sampling port	1 Bulk (tanker) load/generator/ waste stream/ 24-hours	Physical Description	Visual Inspection
				Specific Gravity, <1.2	ASTM D1429-76 Method by weight
	Container, Totes, or Drum Liquids	Coliwasa unit or open tube sampler, tank sampling port or four-foot glass tube.	10% of each container shipment if from same WSP, otherwise 100% of shipment	pH, >2.0-<12.5	SW-846 Method 9040
				Percent Solids, <5%	Adaptation Standard Methods of Water and Wastewater Method 2540
				Cyanides, <0.1	HACH Test
				Sulfides, <0.1	HACH Test
	Temporary Storage Tanks	Tank sampling port	Prior to Injection	Flammability/ Flashpoint, >140°F	ASTM D3828, EPA Method 1010
				Conductivity	SW-846 Method 9050

TABLE IX-D

INJECTION WELL SUMMARY

WDW No.	Status	Injected Volume (gallons)	Maximum Permitted Injection Rate[1] (gallons/year)	Number of Years Utilized	Date in Service
IW-1	Proposed	0	53,647,920	0	Pending

[1] Assume 365.25 days/year.

APPENDICES

APPENDIX

IX-1 Waste Analysis Plan (WAP)

Appendix IX-1

Waste Analysis Plan
for North Texas Industrial Facility

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ATTACHMENT A Site Diagram and Facility Layout

ATTACHMENT B Waste Stream Profile Form

ATTACHMENT C NTI Standard Operating Procedures

ATTACHMENT D Process Flow Diagram

1 INTRODUCTION

The purpose of this Waste Analysis Plan (WAP) is to identify and document the necessary sampling methodologies, analytical techniques and overall procedures which are undertaken for all wastes that enter the North Texas Industrial (NTI) Facility for storage or disposal. Specifically, the plan delineates the following:

- **Pre-Acceptance Procedures** - Section 2 outlines the procedural steps NTI will take to evaluate the acceptability of a candidate waste stream according to permit conditions and operating capabilities prior to shipment and acceptance of the waste for management at the site, including re-evaluation frequency.
- **Acceptable Wastes** - Section 3 summarizes the wastes that NTI is applying to accept.
- **Waste Analyses Performed by North Texas Industrial (NTI) Facility** - Section 4 describes the analyses that will be performed on incoming shipments and wastes in process operations.
- **Restricted Wastes** - Section 5 summarizes wastes that NTI facility is not approved to accept.
- **Rejection Policy** - Section 6 discusses the policy and procedures that NTI will use for the acceptance or rejection of waste received by the facility.
- **Discrepancy Policy** - Section 7 discusses the procedures NTI will use for resolving manifest discrepancies and discrepancies between incoming waste shipments and their waste profile.
- **Sampling Methodology** - Section 8 outlines the proper sampling method(s) for a given waste type (sludge, liquid) and containment (drum, tank, etc.). NTI personnel will obtain waste identification samples to help ensure accurate analytical results when a waste is analyzed.
- **Analytical Parameters, Techniques and Rationale** - Section 9 outlines the parameters, rationale and methods NTI will utilize to determine or identify certain waste properties to ensure proper management of the waste at the site.
- **Quality Control Policy** - Section 10 outlines the quality control policy this site will follow to achieve high-quality analytical results.
- **Data Reporting** - Section 11 identifies the data that NTI will supply to the TCEQ under this WAP.
- **Recordkeeping**- Section 12 identifies the records that NTI will retain on site related to waste analyses performed under this WAP.
- **Corrective Action** - Section 13 describes the procedures that NTI will take to resolve issues, needs or problems that may arise in connection with its laboratory operations.

The Environmental Manager, Plant Superintendents or their designees are individually and collectively herein referred to as "NTI site management".

1-1 FACILITY DESCRIPTION

North Texas Industrial (NTI) Facility is a commercial nonhazardous waste disposal facility located in Itasca, Hill County, Texas. NTI will be comprised of a leachate pipeline, tanker truck unloading area, filtering and treatment area, temporary tank storage area, and a Class I injection well (IW-1). The facility will receive off-site generated nonhazardous industrial wastewater and nonhazardous municipal landfill leachate wastewater. Wastewater received at the facility will be verified by chemical screening, and if acceptable, transferred into above ground temporary storage tanks, where the waste may be comingled with other waste streams prior to disposal in the proposed injection well.

The off-site generated wastes will be managed in a temporary holding facility consisting of a tank farm with up to eight (8) tanks. Each tank will hold up to 750 barrels (bbls) (31,500 gallons (gal)) of wastewater, for a total capacity of 6,000 bbls (252,000 gal). The tank farm will contain a secondary containment area and the associated ancillary equipment. Any wastes generated on-site will be managed in the truck sump, roll-off boxes, and trash dumpsters, and will be disposed of appropriately. Attachment A contains a Site Diagram illustrating the facility layout.

Nonhazardous industrial wastes and nonhazardous municipal landfill leachate will be accepted into this facility by truck shipment, either in bulk (e.g., vacuum truck or tanker truck) or as containerized wastes (e.g., drum, container, tote). Additionally, nonhazardous municipal landfill leachate generated at the Itasca Landfill, LC, will be delivered to the facility via pipeline. The leachate will be sampled and tested weekly to verify consistency with the waste steam profile provided by Itasca Landfill, LC.

Vehicles will enter the facility and proceed to the staging area prior to offloading. The vehicle will remain in this area until the contents of the shipment have been verified and the waste accepted for processing, treatment, and disposal. Once acceptance and verification procedures are completed per the WAP, the vehicle is allowed to proceed to the truck unloading rack.

The delivery vehicle and containers will also be examined while in the staging area for evidence of spillage, leakage, bulging or unsafe conditions. Vehicles and/or containers displaying such conditions will immediately proceed to the truck unloading rack, where waste acceptance and verification can be completed. If the vehicle indicates conditions that will make unloading of the waste unsafe, it will be rejected back to the generator.

Each waste offloading waste management unit includes a curbed concrete area where waste shipments can be safely transferred from the vehicle to the storage tank in an enclosed manner. Any waste spillage during transfer will be contained within the offloading area, where it can be recovered and transferred into the proper storage tank.

Only compatible liquid wastes will be transferred to the storage tanks that are contained in secondary containment areas (the Tank Farm) according to the conditions of the WAP. Incompatible or non-conforming wastes are rejected back to the generator.

Once a tank has been designated for injection, a final screening will be conducted per the WAP, and then the aqueous waste will be pumped via injection line to the proposed injection well.

2 PRE-ACCEPTANCE PROCEDURE

NTI has developed a series of control procedures to determine the acceptability of specific wastes for management at the site, referred to as the "Pre-acceptance Procedures." The pre-acceptance procedures include the following steps:

— **Generator-supplied information** is what a customer must provide to enable NTI to make an initial decision regarding the appropriateness/acceptability and possible management of a candidate waste stream.
— **Initial review and/or analysis of the generator-supplied material** allows NTI to conduct an initial evaluation for management capabilities at the facility.
— **Disposal decision is the process of reviewing all the documentation** supplied by the generator and/or NTI and documenting the acceptance or rejection of the candidate waste stream.
— **Re-evaluation process determines the frequency** a waste stream will be re-evaluated once it has been accepted.

2-1 GENERATOR-SUPPLIED INFORMATION

The waste generator will supply NTI with the Waste Stream Profile Form (Attachment B) for each new candidate waste stream, except where noted herein.

The Waste Stream Profile, (WSP), (Attachment B) will contain pertinent chemical and physical data including a Land Disposal Restriction Certification by the generator. At a minimum, the generator supplies all the information required by 40 CFR 264.13(a)(l) needed to characterize the waste for proper storage and disposal. NTI may assist the generator in completing information provided by the generator based on its evaluation. The WSP will be reviewed and approved by the generator or its representative.

- **Generating process.** The generating process should be described in sufficient specificity. For example, for electroplating, this would include an indication of type of electroplating (zinc electroplating, chromium electroplating, etc.) and a narrative description of the generating process.

- **Raw ingredients used in the generating process.** The waste profile should include a complete list of the ingredients used in the process that generates the waste; and

- **Standard profiles** may be used for waste streams which are similar in physical or chemical characteristics, or which are generated by similar industries or processes. NTI reviews generator-provided information to evaluate whether an individual waste stream is sufficiently similar in physical and/or chemical characteristics to an established standard

profile. The specific waste stream information must fall within the standard profile representative ranges in order to incorporate that waste stream into the standard profile. Specific candidate waste streams which conform to an existing approved standard profile will be managed under the waste management decision for that standard profile.

Refer to Sections 4 and 9 of this WAP for parameters to be analyzed during pre-acceptance.

2-2 INITIAL REVIEW AND ANALYSIS

Once NTI receives the generator-supplied information and it is reviewed, a determination will be made if further analyses by the generator or NTI is required. All waste samples will be subjected to the analyses identified in Section 4, as appropriate. Additional testing may also be requested by the NTI site management, if needed.

If, during the pre-acceptance procedure, NTI determines that the waste information indicated by the testing does not completely conform to the information on the WSP, the generator will be notified of the apparent inconsistency. If the inconsistency is resolved, (i.e. a typographical error on the part of the person completing the WSP form for the generator), the pre-acceptance procedure will continue. If the inconsistency is not resolved, the WSP being considered for disposal at NTI will be rejected.

2-3 DISPOSAL DECISION PROCESS

The pre-acceptance procedure is concluded when the review of the generator supplied information and any appropriate mandatory analyses is complete. At this time, NTI will make a "disposal decision" on the candidate waste. Disposal decisions are based on the following elements:

- Management methods available.
- Conditions or limitations of existing permits and regulations. Capability to safely manage the waste.
- WSP description of the process generating the waste. Knowledge of the waste generating process.
- WSP description of the chemical and physical properties of the waste.
- Any additional documentation supplied by the generator {e.g., LDR certifications). Results of any verification analyses.
- Results of any analyses of process operations procedures. Management's technical experience and judgment.

2-4 RE-EVALUATION PROCESS

In accordance with 40 CFR 264.13{a){3), a waste profile re-evaluation will be conducted when one of the following occurs:

- A generator notifies NTI that the process generating the waste has changed;
- The results of inspection or analysis indicate that the waste received at the facility does not match the identity of the waste designated on the accompanying manifest {or shipping paper) or pre-acceptance documentation {See Discrepancy Policy in Section 7); or

Throughout the year, all wastes received and managed will be re-evaluated, as follows:

- NTI will comprehensively review of all wastes accepted onsite by comparing the results of fingerprint analyses to the WSPs to identify any pattern of discrepancy (i.e., pH of fingerprinted waste that falls outside its tolerance limits (as described herein) more than 20% of the time). This review will be conducted for each waste on an annual basis from the time each WSP is approved.
- NTI will send all WSP's to the generators annually for their review, revisions if needed, and re-certification. Generators will be asked to re-evaluate each WSP to determine if the generation process (e.g., raw ingredients, generating process) or waste has changed such that a new or revised WSP is needed.

3 ACCEPTABLE WASTES

NTI will accept municipal landfill leachate and Class 1 and 2 nonhazardous waste waters. The Class 1 and Class 2 nonhazardous wastewater and municipal landfill leachate that is accepted may be received in tanker truck quantities, totes, drums or containers, from municipal landfills, industrial, petrochemical, oil field equipment manufacturers, commercial and rural Generators. Additionally, nonhazardous municipal landfill leachate from the Itasca Landfill, LC will be delivered to the NTI facility via pipeline.

Nonhazardous wastes managed are aqueous liquid wastes, nonhazardous municipal landfill leachate and other nonhazardous liquid industrial process wastes. All off-site wastes will meet the following requirements for acceptance:

- Each waste will be classified as nonhazardous under 40 CFR 261 (EPA Regulations for Identifying Hazardous Wastes) and 33 TAC 335, Subchapter R {TCEQ Waste Classification Guidelines);
- Each industrial waste generator and each municipal landfill leachate generator will provide evidence for classifying the individual waste streams as nonhazardous by profiling wastes on the WSP;
- Onsite waste acceptance and verification procedures will confirm the nonhazardous classification of the waste; and
- Onsite waste acceptance and verification will also confirm that each waste stream accepted will be amenable to the storage and process equipment used at this facility.

Wastes received and managed are more particularly described below.

3-1 OFF-SITE WASTES

Certain main categories have been established to describe the materials accepted. These categories are Class 1 and Class 2 wastes described as:

- Municipal landfill leachate; nonhazardous
- Aqueous solutions that contain petroleum hydrocarbons; nonhazardous
- Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table I; nonhazardous
- Aqueous solutions that contain halogenated organic compounds in concentrations less than 1,000 mg/I; nonhazardous
- Aqueous acid wastes; nonhazardous Aqueous organic wastes; nonhazardous Aqueous caustic wastes; nonhazardous Aqueous metallic wastes; nonhazardous
- Other associated wastes such as groundwater and rainfall contaminated by the above authorized wastes, spills of the above authorized wastes, and wash waters and solutions used in cleaning

and servicing the waste disposal well system equipment which are compatible with the permitted waste streams, injection zone and well materials; nonhazardous; and
- Wastes generated during closure of the well and associated facilities that are compatible with the permitted wastes, injection zone and the well; nonhazardous

These categories are generalized and are meant to simplify discussion of the municipal and industrial Class 1 and Class 2 nonhazardous wastewater to be accepted at the NTI facility.

3-2 ON-SITE WASTES

Wastes generated on-site include Class 1 and Class 2 wastes described as:

- Liquid waste generated from processing commingled Class 1, and Class 2 nonhazardous industrial wastes;
- Organic solids and trash filtered from tanker truck unloading and during cleaning operations;
- Liquid wastes collected during shipment unloading; and
- Liquid rainfall collected in rain sump.

The organic solids and trash will be consolidated on site and analyzed for hazardous waste characterization and disposed of according to analysis at an approved Disposal Facility.

Refer to Table IX-A in Section IX of the permit application for the proposed injection well for a complete list of the acceptable wastes that this facility is seeking approval to accept and manage onsite.

4 ANALYSES DURING WASTE ACCEPTANCE AND PROCESS OPERATIONS

As discussed in Section 2, NIT site management will apply pre-acceptance procedures to all received at the facility.

The wastewater that is transported onsite via pipeline will be sampled and verified on a weekly bas.

When a shipment of nonhazardous waste is received at the NTI facility by tanker or truck, verification and inspection of the shipment will be performed. NTI will institute a sampling schedule that will maximize efficiency while ensuring accountability. Since multiple shipments of the same waste from the same generator may be received at the facility each day, NTI will sample and analyze waste from one shipment, per waste type, per generator within a 24-hour period. NTI will verify the actual waste received with that determined in the pre-acceptance phase and ensure proper disposition of the waste for storage and disposal. Waste shipments arriving on-site will not be unloaded until the final waste verification decision is made. Upon final waste verification, the waste will be accepted for management at the site, rejected back to the generator, or sent to an alternative disposal facility.

Verification activities include tanker, container, tote or drum receipt inspection. It also includes chemical screening according to the frequencies specified in this section. Any discrepancies between the verification results and waste profile must be resolved in accordance with the Discrepancy Policy discussed in Section 7 before the shipment can be accepted at the facility. In addition, process operations procedures will be performed to ensure that the waste is managed safely and in accordance with applicable regulations.

Table 1 summarizes the parameters that are examined for each of these screening analyses. Parameters for waste analysis during pre-acceptance are shown in Column 2. Once the waste is approved during pre-acceptance, all incoming shipments are subjected to mandatory verification, including inspections and chemical screening (Column 3- commonly known as the Fingerprint Screening). In addition, supplemental analyses may be performed to resolve discrepancies between the verification results and waste profile (Column 4). Finally, analyses are performed as necessary for injection process operations that are conducted onsite (Column 5). Specifically, for incoming wastes that are placed into storage and prepared for injection, NTI performs verification listed in Column 5 to prior to injection of the waste.

TABLE 1: Analysis Performed by NTI

	Column 2	Column 3	Column 4	Column 5
Screening	Pre-acceptance	Incoming Loads[2]	Discrepancy	Prior to Injection
APPEARANCE/COLOR[1]	X	X	O	NA
SpG[1]	X	X	O	X
pH[1]	X	X	O	X
CONDUCTIVITY[1]	X	X	O	NA
REACTIVE CYANIDES[1]	X	X	O	NA
REACTIVE SULFIDES[1]	X	X	O	NA
FLASH POINT[1]	X	X	O	NA
%TSS[1]	X	X	O	NA
ODOR[1]	X	X	O	NA
TCLP VOLATILES*	O	NA	O	NA
TCLP SEMI VOLATILES*	O	NA	O	NA
TCLP METALS*	O	NA	O	NA
TCLP MERCURY*	O	NA	O	NA
TOTAL PETROLEUM HYDROCARBONS*	O	NA	O	NA
TCLP PESTICIDES*	O	NA	O	NA
TCLP HERBICIDES*	O	NA	O	NA

NOTES

[1]: Screening performed at NTI on-site laboratory.

2: NTI will sample one incoming load per waste type, per generator within a 24-hour period.

*: Screening performed at approved independent state certified or NELAP-recognized Laboratory that uses ASTM and/or SW-846 analytical and test methods.

X: Screening examined for each waste.

O: Screening examined as necessary.

NA: Not applicable.

Column 2: Pre-Acceptance Screening on waste prior to shipment to NTI.

Column 3: Operational Screening performed on each load of waste received at NTI prior to offloading into temporary storage tank.

Column 4: Additional Operational Screening that may be performed on a load of waste received at NTI prior to offloading if the waste does not meet the Waste Stream Profile. If the discrepancy is resolved, the load is unloaded into temporary storage tanks. If the discrepancy is not resolved, the load is rejected back to the generator.

Column 5: Operational Screening performed on each temporary storage tank of waste prior to injection into the proposed injection well.

TABLE 2: Summary of Frequency of Analysis

Pre-Acceptance	Incoming Shipments		Pre-Injection
Mandatory	Mandatory[1]	Supplemental	Process Operations
On each waste undergoing pre-acceptance.	On each incoming shipment as follows: • Visual inspection of each shipment, including inspection of opened containers to confirm physical description • Chemical screening of each bulk load • Chemical screening of 10% or more of each container, tote or drum shipment as determined by NTI site management. (See Section 4-1.2 of this WAP for additional information.)	Whenever a discrepancy between waste and WSP is found that cannot be resolved by generator and NTI.	Chemical screening of each tank to be injected. See Table 1, Column 5 for additional information.

NOTE

[1]: Screening performed at NTI on-site laboratory.

The following sections provide more information on the analyses that NTI site management will perform.

4-1 VERIFICATION OF INCOMING SHIPMENTS

Verification of incoming shipments involves inspection of containers and chemical screening. As part of the facility's training program, personnel are taught how to perform the verification procedures effectively and safely.

4-1.1 Visual Inspection

The container receipt inspection is a mandatory element of the confirmation process. Therefore, 100 percent of the incoming bulk shipments and 10% of container, tote or drum shipments are inspected and physically verified for damage, and to ensure the waste containers are those indicated on the documentation (See Section 4-1.2 for additional information relating to container, tote and drum shipments). This activity is a mechanism for identifying any document discrepancies or damaged containers before acceptance.

The container receipt inspection is performed by NTI personnel, who will ensure that the shipment received is:

- received in good condition and does not include bulging or other irregularities,
- the waste indicated on the manifest or shipping papers, and
- complete.

In addition, the vent on each container from each profiled waste in a shipment will be opened and its contents will be visually inspected to confirm it matches the physical description on its profile. The visual inspection will address color, viscosity, and waste form (e.g., debris, sludge), at a minimum.

4-1.2 Chemical Screening

Chemical screening is considered an additional verification element. Selection and interpretation of the appropriate chemical screening method(s) are conducted by NTI personnel who are qualified to perform the screening. The objective of chemical screening is to obtain reasonable assurance that the waste received by NTI is consistent with the description of the waste on the waste profile and to provide information that will be used to safely manage the waste at the NTI facility.

All incoming wastes are inspected as outlined in Section 2 to assure that readily observable characteristics (color, form, absence or presence of odors, size, etc.) are consistent with pre-acceptance data.

Fingerprint testing provides general waste identification and confirmation. Results are compared with pre-acceptance information to confirm that the waste is the same. Results may be used in conjunction with other waste analyses and information to further identify a waste and/or ensure the waste is suitable for storage and injection via deep well.

Specific fingerprint tests are performed during pre-acceptance to identify the characteristics of the waste and ensure the waste matches the pre-acceptance waste material set forth in the WSP.

The following Fingerprint analyses is employed:

- Physical Description
- Specific Gravity
- pH Screen
- Cyanides Screen
- Sulfide Screen
- Flammability Potential Screen
- %TSS
- Conductivity
- Water Mix Screening
- Temperature

As shown in Table 2, NTI will sample and analyze waste from one shipment, per waste type, per generator within a 24-hour period. When sampled, the bulk load (i.e. tanker truck) and ten percent (10%) of each tote, drum, container shipment will be screened chemically. Samples from the top, middle and bottom of each load will be obtained.

4-1.3 Discrepancy Resolution

Discrepancy issues identified during verification of any shipment (i.e., bulk or container) could result in a waste container that does not meet NTI waste acceptance criteria. If a possible discrepancy issue is identified, the actions described in Section 7 of this WAP must be taken.

4-1.4 Supplemental Verification

If the mandatory verification of incoming shipments identifies a discrepancy with the WSP, and the discrepancy cannot be resolved by the generator, then NTI will reject the waste back to the generator or send it to an alternative disposal facility. If necessary, NTI will require supplemental analysis of the waste prior to further shipments of the profiled waste. A supplemental analysis includes tests for the parameters shown in Table 1 in Section 4.

Any waste that is to be rejected will be quarantined within its tanker or container and held in place until the waste exits the NTI facility.

Supplemental analysis will be subcontracted to an independent state certified or NELAP-Recognized Laboratory that uses ASTM and/or SW-846 analytical and test methods. The results of all supplemental analyses will be documented in a log maintained as part of the facility operating record.

4-1.5 Final Acceptance

Upon verification that a waste is consistent with the corresponding WSP, the waste will be moved from the unloading area to an appropriate temporary storage tank and commingled with other wastes prior to disposal into NTI's proposed injection well.

Any waste that does not conform to the corresponding WSP will be rejected and returned to the generator.

4-2 PROCESS OPERATIONS PROCEDURES

Many of the analyses needed for the storage, treatment, and disposal functions are performed during incoming load identification. These are not repeated unless it is known or believed that the waste characteristics may have changed during storage and monitoring of the changes is necessary. Existing and anticipated process operations at the facility, for which current and periodic sampling and analyses is important, include the following:

- Storage
- Comingling
- Injection

The analytical procedures for each of these processes are described separately below.

4-2.1 Storage

When waste is received at the NTI facility, a verification analysis (Fingerprint) will be performed to determine its physical and chemical properties (e.g., pH, flammability, etc.). NTI site management will review the results of the verification analyses to determine the safe management of waste to be placed in storage.

Based on the verification analysis, NTI site management will determine the compatibility of the waste with the storage unit materials of construction and with wastes already stored therein. Liquid wastes which are transferred from tanker trucks, drums or portable tanks may be comingled and placed in bulk storage tanks after the water mix screening test has been performed as described in Section 4.2.2.

4-2.2 Commingling

Following chemical screening, compatibility of the waste with the storage and process equipment will be determined via a water mix screening test. Onsite waste acceptance and verification will confirm the waste determination as nonhazardous prior to offloading the waste shipment and confirm the compatibility of the waste with the waste storage and disposal systems. The parameters that will be used to determine compatibility are as follows:

Prior to a waste being commingled with other wastes, it is tested to verify compatibility. A representative sample of the waste is mixed with a representative sample of the wastes to be commingled. This is done under controlled conditions by personnel trained regarding chemical reactions.

Representative portions of the wastes to be commingled are mixed together at the same measured temperature to verify compatibility. For example, if a partially full container is to be consolidated into another partially full container, a representative sample will be drawn from both containers, and the samples will be mixed. The mixture will be observed for the following:

Stratification - The general miscibility of the materials will be examined. If stratification would appear to create a problem, the materials will not be combined, and the waste will be rejected.

Heat Generation - Materials that upon mixing would generate sufficient amounts of heat or undergo exothermic reactions strong enough to exceed the design capability of the storage unit will not be combined, and the waste will be rejected.

Gas Evolution - Materials that upon mixing liberate flammable, explosive or toxic vapors, fumes or mists in quantities of concern, will not be combined, and the waste will be rejected.

Undesirable Reactions - Materials that upon mixing result in the formation of a large amount of precipitate or in the solidification or gelling of the mixture to an un-pumpable viscosity, making it unsuitable for storage, processing equipment, and injection, will not be combined, and the waste will be rejected.

Once compatibility is determined suitable the liquid wastes are transferred from tanker trucks, drums or portable tanks and may be comingled and placed in bulk storage tanks.

4-2.3 Injection

Prior to a storage tank being injected, the single waste stream or commingled waste will be tested a third time for pH and Specific Gravity prior to the tank being approved to commence injection into the deep well.

5 RESTRICTED WASTE

NTI does not accept for disposal any current production waste or outdated products which are listed as hazardous waste by EPA because it contains, as a hazardous constituent (see 40 CFR Part 261, Appendix VII}, a form of polychlorinated- dibenzo-dioxin (PCDD) or polychlorinated- dibenzo-furan (PCDF} (e.g., F020, F021, F022, F023, F026, F027, etc.).

NTI also does not accept the following wastes:

- PCB Waste, as defined by the Environmental Protection Agency (EPA) in regulations issued pursuant to the Toxic Substances Control Act under 40 CFR Part 761
- Radioactive materials/wastes unless the permittee is authorized to store and process these wastes in compliance with specific licensing and permitting requirements under Chapter 401 of the Texas Health and Safety Code.
- Any low-level radioactive waste as defined by Texas Health & Safety Code §401.004;
- Any naturally occurring radioactive material (NORM} waste as defined by Texas Health & Safety Code §401.003(26); and
- Any oil and gas NORM waste as defined by Texas Health & Safety Code §401.003(27}.
- Explosive material, as defined by the Department of Transportation under 49 CFR Part 173.
- Ignitable compressed gases
- Garbage as defined in 30 TAC Section 330.3(56)
- Municipal Solid Waste as defined in 30 TAC Section 330.3(90)
- Putrescible Waste as defined in 30 TAC Section 330.3(122)
- Special Waste from Health-Care Related Facilities subject to 25 TAC Part 1 or 30 TAC Chapter 330
- Hazardous wastes as defined under 40 CFR §261.3(a) through (d), issued according to the Resource Conservation and Recovery Act and the Hazardous and Solid Waste Amendments, which are regulated by the Commission as authorized by the United States Environmental Protection Agency (EPA), including but not limited to any listed hazardous waste or a waste derived from the treatment, storage or disposal of a listed hazardous waste;
- Any by-product material as defined by Texas Health & Safety Code §401.003(3}

6 REJECTION POLICY

The purpose of this section is to set forth the policy and procedures that NTI will use for the acceptance or rejection of waste received by the facility.

Manifest discrepancies are resolved, if possible, by contacting the generator, transporter, or their representative to obtain the needed information. Entire loads or portions of loads may be rejected (e.g., a bulk load may contain un-profiled or unacceptable materials). The requirements of 40 CFR 262 Subpart B "Manifests" are followed when documenting rejection of waste loads and their return to the generator.

6-1 AUTHORITY

NTI site management has the responsibility of insuring that the appropriate chemical screening of incoming shipments of waste has been performed. They have the authority for acceptance or rejection of each shipment.

6-2 SAFETY

The transporter delivering waste to the facility will abide by NTI's internal safety and operational requirements. Transporters will use trucks equipped with safety items and other necessary equipment so the unloading of the materials can be accomplished safely. Inadequate or unsafe equipment is reason for rejection of any shipment.

6-3 SCHEDULING

All incoming shipments of waste shipments will be scheduled with NTI in advance. A shipment arriving without the necessary pre-scheduling may be rejected or may be significantly delayed by placing the shipment behind all scheduled loads on site at the time.

6-4 DOCUMENTATION

All shipments of incoming waste material must be accompanied by:

- A manifest that complies with state and federal nonhazardous waste regulations; and.
- Any other documentation required for the transport of said material to the facility.

Incoming shipments arriving without a manifest will be rejected with no exceptions.

6-5 NOTIFICATION

In the event that an incoming shipment must be rejected, the onsite personnel will give notification to the following entities:

6-6 REJECTION

A rejected shipment at NTI's facility will be returned to the generator. The generator will be notified that the shipment has been rejected.

7 DISCREPANCY POLICY

Upon arrival of a waste shipment at NTI, the accompanying manifest is reviewed for completeness and the shipment is inspected for agreement with the manifest information.

As used in this WAP, a "discrepancy" is either:

— A manifest discrepancy per 40 CFR 264.72, which includes significant differences between the quantity or type of waste designated on the manifest or shipping paper, and the quantity or type of waste the facility actually receives (described further below); rejected waste; and container residues. Significant differences include:

- For bulk wastes, variations > 10% difference in weight
- For containerized waste, variation in piece count.
- Variations in type discovered by inspection or waste analysis.

— A discrepancy between the chemical or physical properties of a waste received at the facility and its waste profile (e.g., pH that falls outside of its tolerance limits, flammability, etc.). Refer to Section 9 of this WAP for information on the parameters verified for incoming shipments and examples of discrepancies.

Non-conforming wastes may be rejected immediately or may be re-evaluated for acceptance despite the inconsistency. Changes to the manifest or WSP may be made with the customer's concurrence or at the customer's request. Other manifest discrepancies may be corrected or noted on the manifest.

For bulk loads manifested by weight, the load is typically weighed on site. However, if the scale is out of service, other methods may be employed to estimate the weight of the delivery. These include off-site scales, weight estimation techniques, and using tare weights to calculate approximate net weights.

7-1 MANIFEST DISCREPANCY

Manifest discrepancies are resolved, if possible, by contacting the generator, transporter, or their representative to obtain the needed information. Entire loads or portions of loads may be rejected (e.g., a bulk load may contain un-profiled or unacceptable materials).

7-2 DISCREPANCIES BETWEEN WASTE RECEIVED AT FACILITY AND WASTE STREAM PROFILE

If a discrepancy between the waste received at the facility and its waste profile is identified, NTI will perform the following before acceptance:

The generator is notified and requested to supply additional knowledge to assist in the resolution of the concern(s). If the generator supplies information that alleviates the concern(s) identified, no further action is required.

NTI site management and the generator discuss the discrepancy issue and identify the appropriate course of action to resolve the container/shipment in question. If the discrepancy issue(s) results in the failure of a shipment, the chemical screening frequency for all streams that could exhibit a similar issue(s) from the generator are adjusted to 100 percent until the issue(s) adequately can be addressed.

On resolution of the initial discrepancy issue, NTI site management requests the generator to provide a corrective action plan (CAP) that clearly states the reason for the failure and describes the actions to be completed to prevent re-occurrence. The generator could request a reduction in verification of additional streams that the generator believes are unaffected. This request must be accompanied by a justification that identifies why this stream(s) would not exhibit the same discrepancy issue.

NTI site management reviews the CAP and stream justification for adequacy. If the stream justification is adequate, NTI site management could provide an alternative frequency. NTI site management documents these actions and keeps this documentation in the operating record in accordance with Section 12.

8 SAMPLING METHODOLOGY

8-1 GENERAL METHODS AND EQUIPMENT

As practicable, the sampling techniques used for specific types of waste correspond to those referenced in 40 CFR 261, Appendix I and presented in Table 3. Because Appendix I sampling methods have not been formally adopted by the EPA Administrator, NTI may modify the technique as necessary to obtain a representative sample. Any changes made after final permitting will be forwarded to the TCEQ for review and permit modification of NTI' UIC and ISW permits.

The sampling equipment and procedures described in this WAP represent the facility's recommended sampling protocol for general types of waste material and containment. Specific waste materials or shipments may require different sampling techniques. Therefore, deviations from the recommended protocol do not constitute a departure from acceptable sampling practices or the conditions of this WAP. All methodologies will be updated and revised as the references are updated and revised.

Sampling and analysis are commonly performed by waste generators or their representatives at the generator's facility. Specific sampling procedures are dependent on both the nature of the material and the type of containment. This section presents sampling methodologies to be utilized on-site by NTI personnel.

8-2 GENERAL METHODS AND EQUIPMENT

When a waste shipment arrives on-site, a determination has already been made by the generator that the waste is a solid waste which is nonhazardous waste, as defined by 40 CFR§261.4(b).

As shown in Table 3, each bulk load (i.e., each tanker truck) will be screened chemically. Samples from the top, middle and bottom of each load will be obtained.

Container shipments will be chemically screened (i.e., each container) based on whether the shipment originates from the same WSP. Samples from the top, middle and bottom of ten percent (10%) of container shipments will be screened as shown in Table 3. Ten percent (10%) of container shipments will be screened as shown in Table 3 if the container shipment originates from the same WSP, however, if the container shipment originates from more than one WSP each container is chemically screened.

The generator's waste characterization normally includes an analysis of a representative sample of the waste. Waste generators may also provide data originally used to characterize wastes or provide existing analytical test data. The generator or an independent laboratory, may perform analyses using standard test methods (EPA, ASTM, or other approved standards) or alternative methods approved by the EPA or TCEQ.

NTI also evaluates the candidate waste for additional characteristics that may exclude the waste from acceptance at NTI.

Each WSP includes a generator certification statement that states, "On behalf of the above designated generator Company, I hereby certify that the information provided on this Waste Stream Profile, together with the other materials attached hereto, comprises and constitutes a complete and accurate description of the above listed waste material; reveals any and all known or suspected hazards involved in handling, transporting, storing, or processing, and disposing of same, and that no deliberate or willful omissions or misrepresentations as to the composition and properties therefor have been made. Furthermore, I hereby certify that the waste described herein is not subject to the Land Disposal Restrictions as described in 40 CFR Part 268."

See Attachment B for an example of the WSP form.

TABLE 3: Sampling Methods and Equipment

Sampling Location[1]	Sampling Equipment	Sampling Frequency
Bulk Liquids	Coliwasa unit or open tube sampler, or tank sampling port	One shipment, per waste type, per generator within a 24-hour period.
Container, Totes or Drum Liquids	Coliwasa unit or open tube sampler, tank sampling port or four-foot glass tube.	10% of each shipment if from same WSP, otherwise 100% of Shipment
Temporary Storage Tanks	Tank sampling port	Prior to Tank Injection

NOTE:

[1] : Sampling performed at NTI facility upon waste receipt.

8-2.1 Containers and Tanks

A container is a portable device in which a material is stored, transported, disposed of, or otherwise handled. The sampling of small containers (e.g., drums, cartons, and other small units) varies with the physical nature of the waste material. For flowable materials, the sampling device of choice is either a Coliwasa unit or open tube sampler, which is used to draw a full vertical section. Drums of aqueous and organic liquids are sampled with a four-foot glass tube. A composite sample may be obtained by mixing equal portions of each container included in the sampling lot.

9 PARAMETERS AND ANALYTICAL METHODS

NTI will use either SW-846 or ASTM methods for each parameter, as shown Table 4. NTI has its own laboratory SOPs which the NTI onsite lab follows as indicated on Table 4, and as located in Attachment C. The analytical parameters and techniques used by NTI through its operating experience have been chosen for their ability to provide the information required to properly manage a waste.

TABLE 4: Analytical Parameters, Reference Methods, NTI Method, and Rationale

Parameter[1]	Test Method	NTI Method # (See Attachment C)	Purpose
Physical Description	Not applicable	Visual Inspection	Verification and system compatibility
Specific Gravity: <1.2	ASTM D1429-76 METHOD by weight	LAB-003	Verification and system compatibility
pH: >2.0 - <12.5	SW-846 METHOD 9040	LAB-004	Verification and system compatibility
Percent (%) Solids: <5	Adaptation Standard Methods of Water and Wastewater Method 2540	LAB-005	Verification and system compatibility
Cyanides: <0.1	HACH TEST	LAB-006	Verification and system compatibility
Sulfides: <0.1	HACH TEST	LAB-007	Verification and system compatibility
Flammability/ Flash point: >140°F	ASTM D3828, EPA METHOD 1010	LAB-009	Verification and system compatibility
Discrepancy Parameters	N/A	LAB-010	Verification and system compatibility
Conductivity	SW-846 METHOD 9050	LAB-013	Verification

Attachment D contains the Process Flow Diagram illustrating the process flow as wastewater enters the facility.

Following is a discussion of the method(s) and rationale for each verification chemical screening parameter performed as wastewater enters the facility:

Physical Description is observed for every waste to determine its general properties (color, physical appearance, viscosity, texture, presence of absence of odors or debris, etc.). Physical description screening is performed by visual inspection of the waste. Waste that varies significantly from the pre-screened WSP may be deemed non-conforming. Examples of differences in appearance, viscosity, layering, etc. The significance of these variances will be judged in conjunction with variances in the analytical screening listed below.

Specific Gravity screening is used to determine the density of the waste. ASTM D1429- 76 Method by weight is used to determine the specific gravity of the waste. Wastes that vary+/-0.05 specific gravity are considered non-conforming and are rejected back to the generator.

pH Screen measures the corrosive nature of the waste, but commonly is not used for organic wastes, oily waste, or other wastes which are not water soluble. For waste that vary by +/- 2 pH units are considered non-conforming and are rejected back to the generator. If waste received is within the variance, however it falls outside the permit parameters of pH <2.0 and pH >12.5, the waste is non-conforming and rejected back to the generator. Method SW-846 Method 9040 is used for pH screening.

Cyanides Screen indicates whether the waste can produce hydrogen cyanide gas upon acidification below pH 2. Screening for reactive Cyanides is performed by the Hach Test method. If the waste received results in screening of more than <0.1 mg/I the waste is rejected back to the generator. No tolerance is allowed for this screening. Wastes that vary+/- 10% are considered non-conforming and are rejected back to the generator.

Sulfide Screen indicates whether the waste has the potential to produce hydrogen sulfide gas upon acidification below pH 2. Screening for reactive Sulfides is performed by the Hach Test method. If the waste received results in screening of more than <0.1 mg/I the waste is rejected back to the generator. Wastes that vary+/- 10% are considered non-conforming and are rejected back to the generator.

Flammability Potential Screen is used to indicate the fire-producing potential of the waste. This testing is applied to all waste liquid. A waste is ignitable if it is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has a flash point of less than 60 °c (140 °F), as determined by ASTM D3828, EPA Method 1010. Received waste is unacceptable for storage and disposal if the chemical screening is at or below 60 °c (140 °F) and the waste must be rejected back to the generator. Wastes that have a flash point+/- 20°F are considered non-conforming with the WSP and are rejected back to the generator.

% **TSS** determines the suspended particles, that are not dissolved, in a sample of water that can be trapped by a filter that is analyzed using a filtration apparatus. This indicates whether the received waste will be amenable to the filtration that occurs during unloading of the waste. An adaptation of Water and Wastewater Method 2540 is used for this screening. The typical percent for TSS is below 5%. Any waste with TSS greater than 5% will be rejected.

Conductivity screening is used to determine the measure of the waste's capability to pass electrical flow. SW-846 Method 9050 is used for conductivity screening.

Water Mix Screening is used to determine whether the waste has a potential to vigorously react with water to form gases or other hazardous products, or whether it generates significant heat. This testing may not apply to wastes that are already in contact with excess water, or for which sufficient analytical data exist that indicate no potential reactivity with water.

Temperature is measured to determine the safety of NTI personnel during unloading operations, and equipment during unloading and transfer to storage tanks.

10 QUALITY ASSURANCE /QUALITY CONTROL

The following Quality Assurance/Quality Control (QA/QC) information for the NTI facility is being provided as required by 40 CFR 270.30(e).

This section does not provide specific performance standards or quality control procedures for individual sampling and analysis techniques. Such specifics are defined on a corporate- wide basis for NTI. The specific performance standards are dynamic and are revised as warranted to reflect technological advances in sampling and analytical techniques. NTI QA/QC policies are found in the corporate Quality Assurance and Control Policies, portions of which have been extracted and included in the following sections. The performance standards are available for review at the facility.

10-1 SAMPLING PROGRAM

Sampling procedures for facility operations are described in Section 8 of the WAP. The selection of the sample collection device depends on the type of sample, the sample container, and the sampling location. The selection and use of the sampling device are supervised by the NTI QA Manager, who is thoroughly familiar with both the sampling and analytical requirements. The type of device to be used in the various sampling situations is specified in Section 8-2, Specific Methods and Equipment.

Sampling equipment is constructed of non-reactive materials such as glass, PVC plastic, aluminum, or stainless steel. Care is taken in the selection of equipment to prevent contamination of the sample and to ensure compatibility of materials. The specific material of construction to be used for each sampling activity is specified in Section 8-2.

Sampling is performed for each waste stream in a manner that ensures the samples are as representative as possible under the conditions of the sampling event. Full vertical sections are drawn from tanks and containers, where appropriate and where access allows, as described in Section 8-2.

NTI will sample and analyze waste from one shipment, per waste type, per generator within a 24-hour period. When sampled, the bulk load (i.e. tanker truck) and ten percent (10%) of each tote, drum, container shipment will be screened chemically (see Section 4). All samples must be appropriately labeled. No field notebook is used in sampling waste shipments or process samples. Anything unusual noted during sampling would be noted in the comments area of the label. No chain of custody form is employed within the plant. The samples are turned directly into the lab. A chain-of-custody form will accompany any sample being sent to a third-party lab. Sampling information is kept in the facilities operating records.

10-2 ON-SITE FIELD LAB EQUIPMENT

In order to ensure data quality, the on-site field lab equipment capable of calibration is inspected and calibrated daily and calibration records are maintained on file for review by TCEQ Investigators.

All equipment that comes in contact with waste is kept free of residual materials so that it does not contaminate the true physical or chemical composition of the waste being screened by the equipment. This quality assurance involves:

- All equipment and containers are cleaned thoroughly and decontaminated prior to use.
- All sampling equipment is decontaminated after each sampling event.
- All loose debris and/or soil is removed from the sampling equipment, followed washing with an inert detergent solution.
- As a final step, the equipment is rinsed with an appropriate solvent followed by rinse with deionized water.

10-3 CALIBRATION FREQUENCY

Table 5 illustrates calibration frequency for on-site field lab equipment used for verification Fingerprint analysis.

TABLE 5: Calibration Frequency

Equipment	Frequency of Calibration
SpG	As recommended by the instrument manufacturer
pH	As recommended by the instrument manufacturer
Conductivity	As recommended by the instrument manufacturer
Reactive Cyanides	N/A
Reactive Sulfides	N/A
Flash Point	As recommended by the instrument manufacturer
% TSS	N/A

10-4 CHAIN OF CUSTODY FOR OFF-SITE ANALYSIS

For all samples sent off-site for analysis, such sample will be accompanied by a Chain of Custody Form. At a minimum, the Chain of Custody form will contain:

— Type of sample
— Date and time of collection
— Parameters of initial analysis to be conducted on sample. date and time of transfer to off-site laboratory
— Names and signatures of any persons involved in transferring samples and the name and signatures of person receiving sample at the off-site laboratory

11 DATA REPORTING

NTI will report discrepancies to TCEQ if they are not resolved within the timeframes specified in 40 CFR 264.72. In addition, NTI will supply any analytical data to TCEQ Investigators when requested. This includes the following information, which is kept at the facility:

- **Receiving Papers** - Date, time, sample ID, customer name, stream ID, and sample receipt/delivery.
- **Worksheet Raw Results** - For each test (instrument readings, sample weights, etc.), date, initials of analyst, and sample ID.
- **Sample Master Logbook** - Date, sample ID, type, initials, result, etc.
- **Calibration and Performance Sample Results** - Initials, result, results of calibrations, duplicates, known standards, blanks, blind samples, and reference samples. QC results are compiled, and each set of results will be compared with QC limits, and records should show the basis for QC limits.

12 RECORDKEEPING

A complete set of records will be maintained at the facility for each generator, including information generated during pre-acceptance, acceptance, and waste treatment. This information will include, but not be limited to:

- WSP
- Fingerprint Analysis SDSs (if available)
- Generator laboratory analysis (if available) Independent laboratory analysis (if available) Photocopy of each manifest
- Records demonstrating compliance with, and decisions made under the analyses performed by NTI facility. In particular, a record of all analyses will be maintained by NTI for each waste sampled/analyzed, as part of the facility operating record. The mandatory and supplemental analyses records will include:
- A copy of the independent laboratory chain of custody document (if applicable)
- Copies of all applicable analytical and test results and lab reports including the results of the mandatory analysis
- A copy of the original (incoming) manifest A copy of the original WSP
- Documentation of any discrepancies identified by Fingerprint Analysis
- If applicable, a copy of any written correspondence with the generator related to resolving a WSP discrepancy and documentation of relevant conversations with the generator regarding same.
- If applicable, copies of any written correspondence with the generator and TCEQ related to resolving a manifest discrepancy and documentation of relevant conversations with the generator or TCEQ regarding same.
- If applicable, a copy of the revised WSP
- Records documenting NTI's records to resolve discrepancies between an incoming waste and its waste profile.

All waste analysis records will be kept as a part of the facility operating record and will be maintained as required by law and available for review by TCEQ Investigators.

13 CORRECTIVE ACTION

While the goal of the NTI QA/QC program is to provide sufficient training, equipment, facilities, technical support, and supervisory oversight to avoid inadequate measurements or data, it is recognized that data quality can fall outside established limits for a variety of reasons. The program provides for reporting and reviewing procedures that permit early and effective corrective action should it be needed.Specifically:

- All samples are registered and tracked via NTI site management to ensure that documentation of the necessary analyses is performed.
- Data generated each day are entered into appropriate logbooks and NTI site management tracks each sample. These systems provide an opportunity for quick review of the data to see if the various results are internally consistent. Apparent discrepancies are brought to the attention of NTI site management.

NTI site management reviews completed data information on all samples prior to shipment receipt. This data is then filed for future reference.

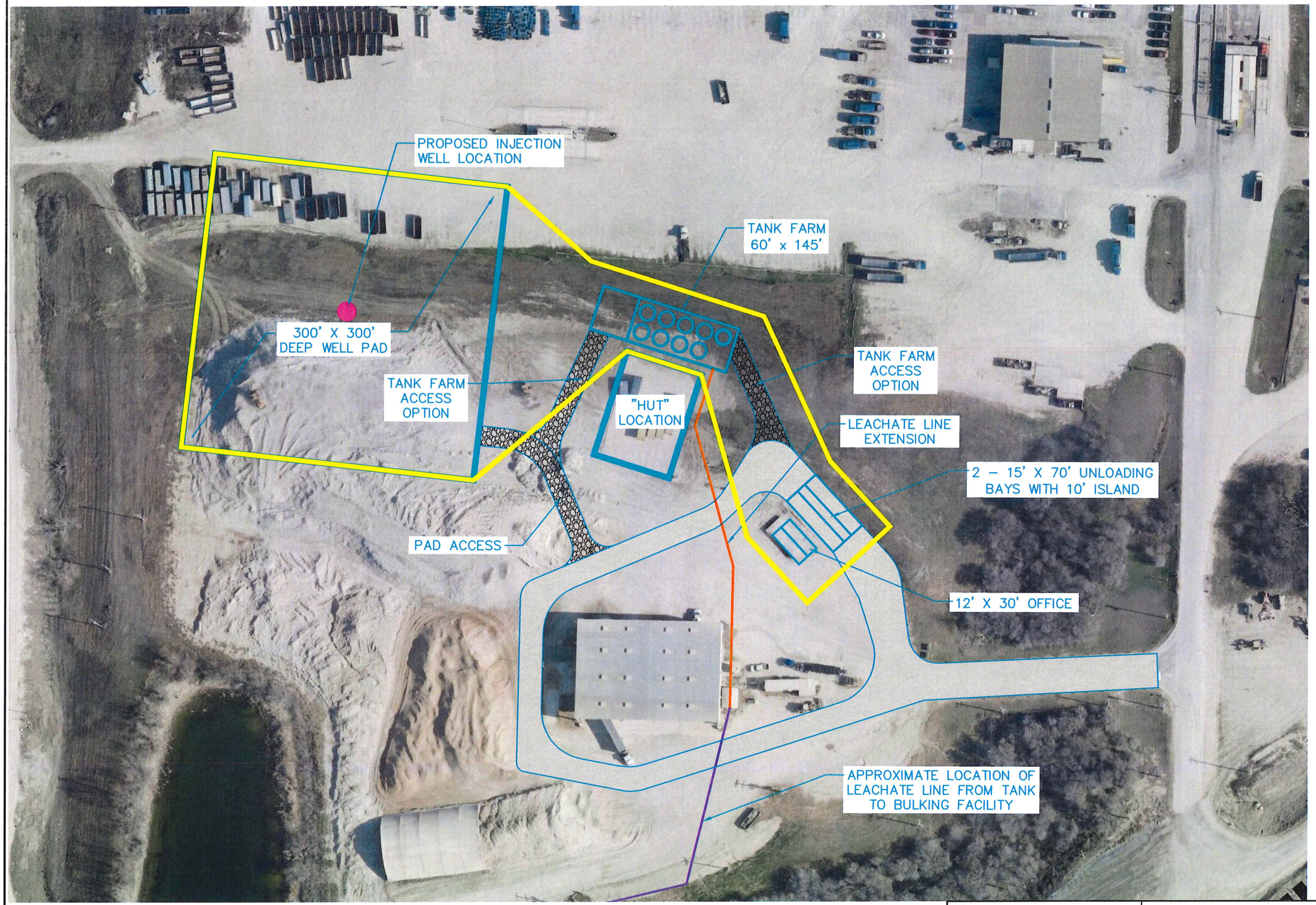
If problems are found, several corrective actions are considered depending on the apparent source. These include, but are not limited to:

- Re-sampling
- Re-analysis of the sample Performance audit of the analyst Systems audit
- Inter laboratory comparison study Review of SOP for error or inadequacy.

ATTACHMENTS

ATTACHMENT A

SITE DIAGRAM OF FACILITY LAYOUT



0 50 100
SCALE IN FEET

NORTH TEXAS INDUSTRIAL FACILITY BOUNDARY

NOTES:

1. AERIAL PHOTOGRAPH PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY, FLOWN 12–06–2019.

Revision 2 - August 2021

☐ DRAFT
☒ FOR INFORMATIONAL PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 11/2020
FILE: 0120–084–10
CAD: 1–DEEP WELL LOCATION OPTIONS.DWG

DRAWN BY: RAA
DESIGN BY: CRM
REVIEWED BY: CRM

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

ATTACHMENT C-1
OVERALL FACILITY LAYOUT

NORTH TEXAS INDUSTRIAL FACILITY HILL COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING 1

P:\Solid waste\Allied\Itasca\Deep Well\Well and Tank Farm Options REV 1.dwg, jwilson, 1:2

ATTACHMENT B

WASTE STREAM PROFILE FORM

Deep Well Profile

Disposal Facility: --Select--

Waste Profile #:

Sales Rep #:

I. Generator Information

Generator Name:

Address:

City: County: State: Zip:

State ID/Reg No: EPA ID #: NAICS #:

Generator Mailing Address ☐ (if different)

City: County: State: Zip:

Generator Contact Name: Email:

Phone Number: Ext: Fax Number:

II. Billing Information

Bill To: Contact Name:

Billing Address: Email:

City: State: Zip: Phone:

III. Waste Stream Information

Name of Waste:

Process Generating Waste:

Is Waste from a TSDF Like Consolidation Process?? ☐ **Yes** ☐ **No**

Waste Type: --Select--

Container Type: --Select--

Container Size / Unit of Measure: Annual Volume: Volume Units: --Select--

Frequency: --Select--

IV. Federal and State Regulatory Information

Is this waste Benzene NESHAP regulated by 40 CFR 61.342? ☐ **Yes** ☐ **No**

Is this waste from State or Federal Superfund Subject to CERCLA? ☐ **Yes** ☐ **No**

State Waste Codes:

RCRA Waste Codes:

Remember to attach Laboratory Analytical Report (and/or Material Safety Data Sheet) including Chain of Custody and required parameters provided for this profil

Deep Well Profile

REPUBLIC SERVICES

V. Shipping / Packaging Information

DOT Hazardous Material / Waste? ☐ **Yes** ☐ **No** UN / NA# _____ Packaging Group: --Select-- Hazardous Class(es): _____

DOT Proper Shipping Name: _____

NOS Hazardous Constituents: _____

ERG#: _____ RQ: ☐ **Yes** ☐ **No** RQ Basis: _____ RQ Value in lbs: _____

Marine Pollutant as defined by 49 CFR 171.8 ☐ **Yes** ☐ **No** If Yes, describe: _____ 24 Hour Emergency Contact Number: _____

VI. Physical Characteristics

Primary Color: _____ % Suspended Solids: --Select-- Layers: --Select-- Specific Gravity: --Select-- Or Actual _____

Odor: --Select-- Odor (describe): _____ pH: --Select-- Dry Weight Ton Per Gallon: _____

Flash Point: --Select-- Flash Point Test Method: --Select-- Total Alkalinity (mg/L): _____ VOC Concentration (ppm): _____ Ammonia / Ammonia Compounds ☐ **Yes** ☐ **No**

VII. Chemical Composition

Chemical Composition (Must add up to 100%) All compounds of >/=1% concentration must be listed.

Constituent (no trade names)	Min	Max	% or ppm	Constituent (no trade names)	Min	Max	% or ppm
			ppm				ppm
			ppm				ppm
			ppm				ppm
			ppm				ppm
			ppm				ppm

Waste Composition is determined by: ☐ Analysis ☐ Safety Data Sheet (SDS) ☐ Process Knowledge

Have you taken a sample? ☐ **Yes** ☐ **No**

Is the representative sample collected in accordance with US EPA 40 CFR 261.20 (c) or equivalent? ☐ **Yes** ☐ **No**

Sample Type: --Select-- Sample ID #: _____ Sample Date (mm/dd/yy): _____

List additional sample ID#(s) and dates and/or list the product name of each SDS submitted: _____

Remember to attach Laboratory Analytical Report (and/or Material Safety Data Sheet) including Chain of Custody and required parameters provided for this profile

Deep Well Profile

REPUBLIC SERVICES

VIII. Chemical Properties

RCRA Items:

Arsenic	☐ None	☐	PPM
Barium	☐ None	☐	PPM
Cadmium	☐ None	☐	PPM
Chromium	☐ None	☐	PPM
Lead	☐ None	☐	PPM
Mercury	☐ None	☐	PPM
Selenium	☐ None	☐	PPM
Silver	☐ None	☐	PPM

State Regulated:

TPH (TX & CA)	☐ None	☐	PPM
Antimony (TX &CA)	☐ None	☐	PPM
Beryllium (TX & CA)	☐ None	☐	PPM
Nickel (TX & CA)	☐ None	☐	PPM
Chromium VI (CA)	☐ None	☐	PPM
Cobalt (CA)	☐ None	☐	PPM
Copper (CA)	☐ None	☐	PPM
Molybdenum (CA)	☐ None	☐	PPM
Thallium (CA)	☐ None	☐	PPM
Vanadium (CA)	☐ None	☐	PPM
Zinc (CA)	☐ None	☐	PPM

Operational:

Bromide	☐ None	☐	PPM
Calcium	☐ None	☐	PPM
Chloride	☐ None	☐	PPM
Fluoride (CA)	☐ None	☐	PPM
Iodine	☐ None	☐	PPM
Iron	☐ None	☐	PPM
Magnesium	☐ None	☐	PPM
Potassium	☐ None	☐	PPM
Sodium	☐ None	☐	PPM
Sulfur	☐ None	☐	PPM

IX. Chemical Properties Certification (Each item must be answered)

PCB's (per 40 CFR 761)	☐ None	☐	PPM	Pathogens	☐ No	☐	Yes. If Yes, please explain:
Benzene	☐ None	☐	PPM	Pesticides	☐ No	☐	Yes. If Yes, please explain:
Dioxins	☐ None	☐	PPM	Polvmerizes	☐ No	☐	Yes. If Yes, please explain:
Sulfides	☐ None	☐	PPM	Radioactives	☐ No	☐	Yes. If Yes, please explain:
Cyanides	☐ None	☐	PPM	Water Reactives	☐ No	☐	Yes. If Yes, please explain:
Oxidizer	☐ None	☐	PPM	Other Reactives	☐ No	☐	Yes. If Yes, please explain:

Pentachlorophenol	☐ No	☐	Yes. If Yes, please explain:
OSHA Carcinogen	☐ No	☐	Yes. If Yes, please explain:

X. Certification

I hereby certify that to the best of my knowledge and belief, the information contained herein is a true, complete and accurate description of the waste material being offered for disposal and all known or suspected hazards have been disclosed. To the best of my knowledge, all Analytical Results/Material Safety Data Sheets submitted are truthful and complete and are representative of the waste. In addition, I certify that all known or suspected hazards involved in handling, transporting, storing, treating or processing, and disposing of the waste material that is the subject of this profile have been disclosed and that no deliberate or willful omissions or misrepresentations as to the composition and properties of the waste have been made. I shall immediately give written notice of any change or condition pertaining to the waste not provided herein. Our company hereby agrees to fully indemnify and hold harmless the disposal facility for any damages or losses resulting from this certification being inaccurate or untrue and for any damages or losses resulting from offering for disposal a waste material that does not conform to this waste profile and certification.

Authorized Representative Name (Printed)	Title (Printed)	Company Name
Representative Signature		Date

ATTACHMENT C

NTI STANDARD OPERATING PROCEDURES

(REFERENCED IN TABLE 4)

NORTH TEXAS INDUSTRIAL FACILITY
STANDARD OPERATING PROCEDURE

SOP Number:	LAB-003/Laboratory
SOP Name:	Specific Gravity by Weight
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY: The ratio of the density (weight per unit volume) of a waste to the same weight per unit volume of a standard (water).	
Attachments and/or Exhibits:	
Keywords	Specific Gravity, Gravity, Weight

EQUIPMENT & REAGENTS NEEDED:

1. Top-loading Balance
2. 120 ml dispo cup
3. 10 ml pipette

QA/QC:

1. Check the balance daily with a standard weight. Record this in the Balance Record Book.
2. Run one duplicate at the beginning of each your shift for the first ten samples and then with every additional ten sample s.

PROCEDURE:

1. Place an empty 120 ml dispo cup on balance and zero (tare) balance.
2. Place l 0.00 ml of sample into the dispo cup.
3. Record weight of the sample to two decimal places in Specific Gravity workbook.
4. Dispose of used cup and sample in appropriate Waste Container.

Calculation of Specific Gravity:

$$\text{Specific Gravity} = \frac{\text{wt. of sample}}{10\text{ ml}} \times \frac{1}{\text{density of water (1)}}$$

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-004/Laboratory
SOP Name:	pH of Water
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY:	
Attachments and/or Exhibits:	
Keywords	pH, Water, Acid, Alkaline, Acidity, Water Acidity, Alkalinity, Water Alkalinity

EQUIPMENT & REAGENTS NEEDED:

1. pH meter and pH probe
2. pH standards 4, 7, and 10
3. Dispo cups
4. Dispo wipes
5. DI water

QA/QC:

1. Calibrate pH meter at the beginning of your shift.
2. Run one duplicate at the beginning of your shift for the first ten samples and then with every additional ten samples.
3. Check your calibration after every ten (10) samples by reading pH 7 solution.

CALIBRATION:

1. Calibrate pH meter with three (3) standard solutions of pH 4, 7, and 10 according to the manufacture instructions.

PROCEDURE:

1. Put a stirring bar in a beaker. (NOTE: The stirring bar should be used unless the sample is less than 10 ml. With less than 10 ml, stir gently while measuring pH.
2. Add sample to beaker, and place on auto-stirrer.
3. With pH meter *in* the measure mode (as noted on screen), lower pH probe(s) into sample.
4. Allow reading to stabilize before you record the pH.

NOTE: Remember to rinse probe(s) with DI and gently wipe dry with a disposable wipe between samples.

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

EQUIPMENT & REAGENTS NEEDED:

1. Top-loading Balance
2. 120 ml disposable cup
3. 10 ml pipette

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-005/Laboratory
SOP Name:	Wet Solids (TSS)
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY: Waste streams must be analyzed for the amount of wet solids in order to predict the amount of filtration needed prior to injection.	
Attachments and/or Exhibits:	
Keywords	Wet, Solids, Wet Solids

EQUIPMENT & REAGENTS NEEDED:

1. Analytical Balance
2. Tongs
3. Gooch crucible (Coors #60148)
4. 1.2 um filter disc (Whatman GF/C 2.1 cm,)
5. Vacuum filtration apparatus

QA/QC:

1. Analyze one (l) duplicate and two (2) blanks with every twenty (20) samples analyzed.
2. If blanks or duplicates are off by± 15% deviation, the entire set of samples must be reanalyzed.

PROCEDURE:

1. Place a dry Gooch crucible (Coors #60148) into vacuum filtration apparatus.
2. Insert a 1.2 um filter disc (Whatman GF/C 2.1 cm.)
3. Wet with deionized water and pull vacuum for thirty (30) seconds. Remove from vacuum apparatus being sure no water drops remain inside the crucible. Tare crucible.
4. Return crucible to vacuum filtration apparatus, tum on vacuum, and dispense 10 ml. of sample through crucible. (Less sample may be used if high solids are expected.) (Never leave sample in crucible, without vacuum, on as solids can seep around filter.)
5. After all liquid sample has passed through filter, follow with 20 ml. deionized water, and pull vacuum for thirty (30) seconds after all water has passed through the filter.
6. Remove crucible and dry off any excess water from inside and outside of crucible, then weigh and record weight in gravimetric.

$$\%TSS = \frac{\text{Final Weight}}{\text{Sample Volume (ml)}} \times 100$$

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.
All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-006/Laboratory
SOP Name:	Cyanide Screen
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY: Waste streams are screened for the presence free of cyanide.	
Attachments and/or Exhibits:	
Keywords	Cyanide, Screen, Cyanide Screen

QA/QC:

1. Run a standard after every twenty-(20) samples.

PROCEDURE:

A. Pretreatment ofsample:
   1. If sample is turbid, filter with filter paper provided.

B. Procedure:
   1. Fill square mixing bottle to the shoulder.
   2. Mix in the contents of one HexaVer Powder Pillow and swirl to mix.
   3. Mix in the contents of one CyaniVer 3 Cyanide Reagent Powder Pillow.
   4. Mix in the contents on one CyaniVer 4 Cyanide Reagent Powder Pillow.
   5. Immediately mix in the contents of one CyaniVer 5 Cyanide Reagent Powder Pillow. If cyanide is present, a pink color will develop and turn blue in a few minutes. Allow 20-26 minutes for full color development.
   6. Fill a color viewing tube to the 5ml mark. Place the tube in the top opening of the color comparator.
   7. Fill the other color viewing tube to the 5 ml mark with untreated water sample. Place it in the left top opening of the comparator.
   8. Hold the comparator up to a light source, rotate the disc to obtain a color match. Read the amount of cyanide present through the scale window. Multiply reading by dilution factor.

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-007/Laboratory
SOP Name:	Sulfide Screen
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY:	
Attachments and/or Exhibits:	
Keywords	Sulfide, Screen, Sulfide Screen

PROCEDURE:

1. Rinse a square-mixing bottle with DI. Fill to the 25ml mark with DI.
2. Rinse a square-mixing bottle with the sample to be tested. Fill to the 25ml mark with the sample.
3. Add 1 ml of Sulfide 1 Reagent to each bottle.
4. Add 1 ml of Sulfide 2 Reagent to each bottle. Swirl to mix. The solution will turn pink then blue if sulfide is present. Let stand for five minutes for full color development.
5. Fill one color viewing tube to within 1/16" of the top with the blank.
6. Fill the other color viewing tube to within 1/16" of the top with the sample.
7. Place the sample in the prepared sample position of the comparator.
8. Place the blank in the left top opening of the comparator.
9. Hold the comparator to a light source and rotate the disc to obtain a color match. Read the total sulfide in mg /1 S2- from the upper scale.

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-009/Laboratory
SOP Name:	Flash Point - Seta Flash
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY:	
Attachments and/or Exhibits:	
Keywords	Flash Point, Flash, Seta, Seta Flash

EQUIPMENT & REAGENTS NEEDED:

1. Seta-Flash Apparatus
2. Ethyl benzene
3. 10 ml Syringe
4. Towels or Teri Wipes

QA/QC:

1. Run an ethyl benzene standard (Flash Point= 64°F) at the beginning of your shi ft.
2. Run one duplicate with every 10 samples analyzed.
3. Record reading in Flashpoint workbook.

PROCEDURE:

1. Make sure the sample test cup is clean and dry.
2. Turn on gas and ignite the flame.
3. Adjust the flame to lowest setting in order to get accurate results.
4. Thoroughly mix sample.
5. Fill l O ml syringe with 2 ml of sample.
6. Assure that the test cup is closed and then inject the sample into the test cup through the injection orifice.
7. Record the initial Temperature and tum the heater on.
8. Open and close the slide to allow the flame to enter the test chamber.
9. Continue to do so every 5 degrees until a visible flash is seen.

10. Record reading in Flashpoint workbook.
11. Turn off the gas and clean sample test cup with teri-wipe.

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis logbook. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

1. Always check tubing and connections for possible leakage of gas by looking for any signs of leakage.
2. Check to make sure the gas is not turned on to maximum output. This could cause a high flame when ignited.
3. Be sure sample is not spilled on the outside or top of the sample test cup. If flammable, this material could catch fire when in contact with the flame.
4. Check for breakage in thermometer. Skin may not touch mercury at any time. If necessary, replace it WHILE WEARING GLOVES to prevent skin contact with mercury.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY

STANDARD OPERATING PROCEDURE

SOP Number:	LAB-010/Laboratory
SOP Name:	Waste Stream Discrepancy Parameters
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY: This method provides a procedure for determining if a waste receipt conforms to the origin al characterization information. Non-conforming receipts must be approved in writing by the Plant Manager, Plant Supervisor, or Technical Director.	
Attachments and/or Exhibits:	
Keywords	Waste, Stream, Waste Stream, Discrepancy, Parameter, Parameters

PROCEDURE:

Discrepancies

1. If the Laboratory Department detects a significant discrepancy between the waste received and the original characterization, the waste is directed to a holding area on the plant site while the Laboratory determines if the discrepancies are significant. Incoming loads that do not conform with previously obtained data are referred to the Laboratory or Technical Manager and are subjected to further analysis before receipt.
2. Waste streams that vary by +/- 2 pH units are considered to be non-conforming to the characterization.
3. Waste streams with wet solids contents that are 5.0% by weight greater than expected are considered to be non-conforming with the characterization.
4. Waste streams that vary +/- 0.05 specific gravity is considered non-conforming with the characterization.
5. Waste streams that have a flash point +/- 20° F are considered non-conforming with the characterization.
6. Waste streams that contain sulfide or cyan ide when none was determined during characterization are deemed non-conforming. Waste streams that vary +/- 10% are considered non-conforming.
7. Waste receipts that vary significantly from characterization representations may be deemed non-conforming. Examples include significant differences in

appearance, viscosity, layering, etc. The significance of these variances will be judged in conjunction with variances in the analytical parameters listed above.

NTI PERMITS REQUIRED:

IW-1

ENVIRONMENTAL CONSIDERATIONS:

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

Wear appropriate Personal Protective Equipment.

All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

NORTH TEXAS INDUSTRIAL FACILITY
STANDARD OPERATING PROCEDURE

SOP Number:	LAB-013/Laboratory
SOP Name:	Conductivity of Water
Preparation/Revision Dates:	May 1999; March 2004
Applicable Departments:	Laboratory
METHOD SUMMARY:	
Attachments and/or Exhibits:	
Keywords	Conductivity, Conductor, Conduct, Water, Water Conductivity

EQUIPMENT & REAGENTS NEEDED:

1. Conductivity meter and conductivity probe
2. Conductivity standard I 000 m icroseimen
3. Dispo cups
4. Dispo wipes
5. DI water

QA/QC:

1. Calibrate conductivity meter at the beginning of your shift.
2. Run one duplicate at the beginning of your shift for the first ten samples and then with every additional ten samples.
3. Check your calibration after every ten (10) samples by reading conductivity standard.

CALIBRATION:

1. Calibrate the conductivity meter with the 1000 mircoseimen standard solution according to the manufacturer instructions.

PROCEDURE:

1. Put a stirring bar in a beaker. (NOTE: The stirring bar should be used unless the sample is less than 10 ml. With less than 10 ml, stir gently while measuring conductivity.
2. Add sample to beaker, and place on auto-stirrer.
3. With the conductivity meter in the measure mode (as noted on screen), lower conductivity probe(s) into sample. (NOTE: Make sure that all air bubbles are out of the probe when placing the probe into the sample.)
4. Allow reading to stabilize before you record the conductivity.

NOTE: Remember to rinse probe(s) with DI.

ENVIRONMENTAL CONSIDERATIONS:

Record all data in the appropriate analysis log book. Analysis results must be retained for five (5) years following analysis completion. Samples must be retained for thirty (30) days following analysis completion.

1. No harm to human life.
2. No harm to environment.
3. No unauthorized release.
4. No exceedance of permitted parameters.

SAFETY CONSIDERATIONS:

All samples should be handled as hazardous material until proven otherwise.

SOP APPROVALS:

TITLE	SIGNATURE	DATE
NTI Plant Superintendent		
NTI Management		

REVISIONS:

NUMBER	DATE	APPROVAL 1	APPROVAL 2

ATTACHMENT D

PROCESS FLOW DIAGRAM

P-100
NON-HAZ. UNLOADING PUMP

P-110
NON-HAZ. UNLOADING PUMP

F-100
MICRON FILTER

F-110
MICRON FILTER

F-120
MICRON FILTER

SK-200
PH NEUTRALIZATION SKID

P-200
METERING PUMP

P-210
METERING PUMP

SK-220
PH NEUTRALIZATION SKID

P-220
METERING PUMP

P-230
METERING PUMP

SK-240
PH NEUTRALIZATION SKID

P-240
METERING PUMP

P-250
METERING PUMP

T-300
LEACHATE INJECTION TANK
500 BBL

T-310
LEACHATE INJECTION TANK
500 BBL

T-320
LEACHATE INJECTION TANK
500 BBL

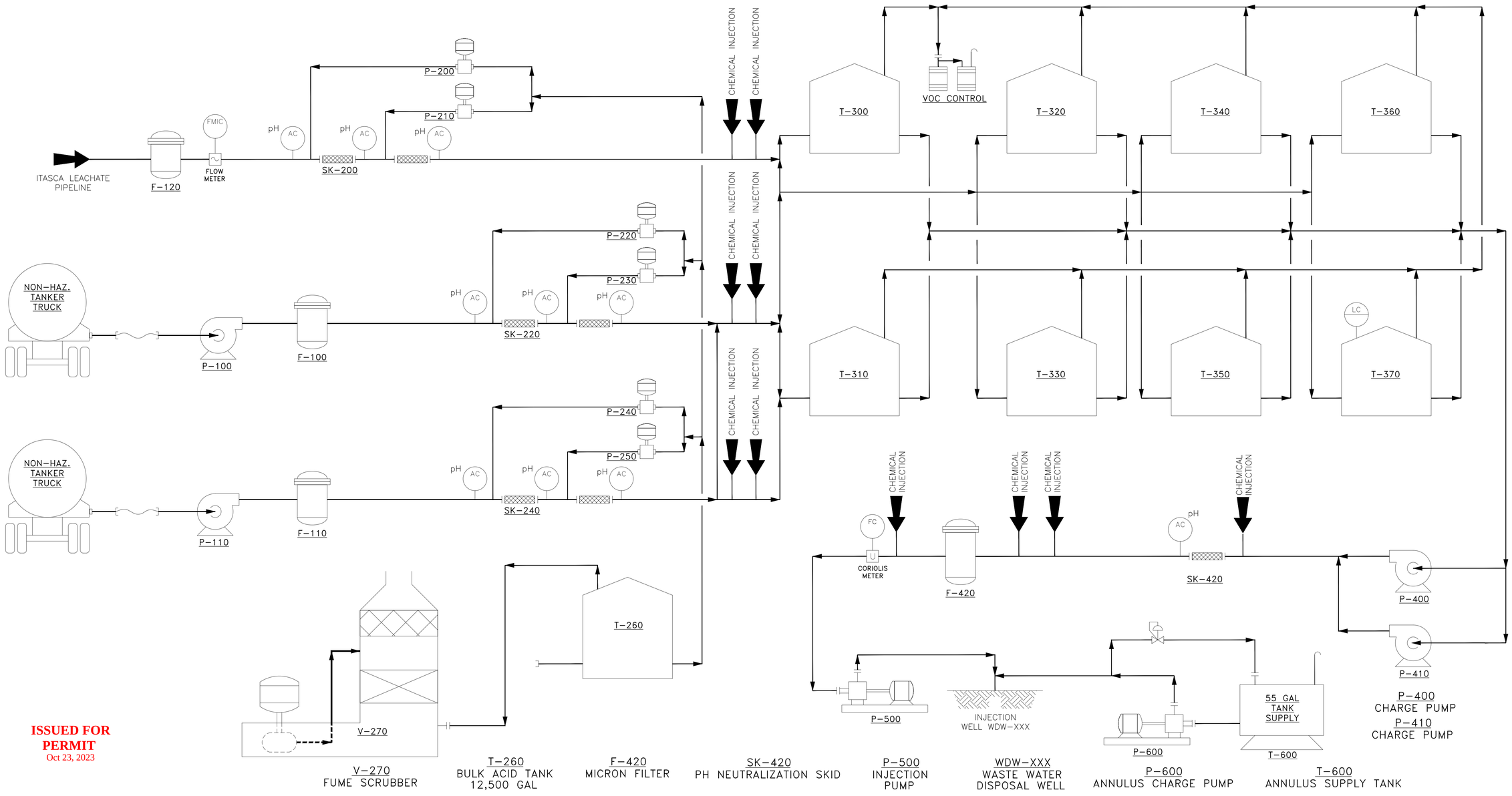
T-330
LEACHATE INJECTION TANK
500 BBL

T-340
LEACHATE INJECTION TANK
500 BBL

T-350
LEACHATE INJECTION TANK
500 BBL

T-360
LEACHATE INJECTION TANK
500 BBL

T-370
LEACHATE INJECTION TANK
500 BBL



V-270
FUME SCRUBBER

T-260
BULK ACID TANK
12,500 GAL

F-420
MICRON FILTER

SK-420
PH NEUTRALIZATION SKID

P-500
INJECTION PUMP

WDW-XXX
WASTE WATER DISPOSAL WELL

P-600
ANNULUS CHARGE PUMP

T-600
ANNULUS SUPPLY TANK

P-400
CHARGE PUMP

P-410
CHARGE PUMP

GENERAL NOTES:

REV.	REVISION	DATE	DRAFT	CHECKED	APP'D.
B	REVISED FOR PERMIT	10/23/23	MJL	–	DAH
A	ISSUED FOR PERMIT	01/13/21	MJL	–	AHN

STATE OF TEXAS
DAVID A. HITDLEBAUGH
108042
LICENSED
PROFESSIONAL ENGINEER
10.23.2023

PELICAN
Energy Consultants, LLC

REPUBLIC SERVICES

TITLE
ITASCA LEACHATE NON HAZARDOUS WASTE INJECTION FACILITY
ITASCA, TEXAS
PROCESS FLOW DIAGRAM

DRAWING APPROVAL

DRAWN BY:	MJL	01/13/21	CHECKED BY:	
DESIGN ENGINEER:			CLIENT APPROVAL:	

CLIENT
REPUBLIC SERVICES

JOB NO. 210106
DWG. NO. 34100

PLOT TIME: October 23, 2023 2:58 PM BY: DAVID HITDLEBAUGH FILE PATH: R:\CLIENT PROJECTS\REPUBLIC SERVICES\ITASCA LEACHATE INLECTION FACILITY\210106\DRAWINGS\30000 MECHANICAL\34000\34100-210106.DWG

X. RCRA PERMIT BY RULE REQUIREMENTS

Not Applicable, the proposed well at the NTI Facility will be utilized for nonhazardous waste disposal.

XI. DISPOSAL OF WASTES CONTAINING RADIOACTIVE MATERIALS

Not Applicable, NTI Facility will not accept or apply to accept waste containing radioactive materials.

XII. PRE-INJECTION UNITS

RIES has applied to operate a commercial, nonhazardous injection well and associated surface facility. RIES has submitted simultaneous to this UIC Application, the TCEQ-0024 Permit Application to Store or Process Industrial Nonhazardous Waste to the Solid Waste division at TCEQ. The Industrial Solid Waste permit was issued April 21, 2022 (Permit No. 98010) and is included in this permit as Appendix XII-1. The issued permit describes the facility and the Pre-Injection Units for the injected waste. Also included at the end of Appendix XII-1 is the Process Flow Diagram (PFD) and Piping and Instrumentation Diagram (P&ID) for the Itasca Facility.

The facility will accept Non-Hazardous waste via tanker truck and non-hazardous leachate via pipeline. Once accepted into the facility, the waste is pumped and metered through a micron filter and pH neutralization skid. The waste then is stored in eight 31,500 gallon storage tanks (252,000 gallon maximum capacity). The waste is then pumped into the injection well system to IW-1.

Table XII is included which lists the summary of the Pre-Injection Units included in the Industrial Solid Waste Permit (No. 98010)

TABLES

TABLE XII

PRE-INJECTION UNIT SUMMARY

Pre-Injection Unit Name	Unit Number or Identifier	Permit Authority
ISW Storage Tank	T-300	TCEQ
ISW Storage Tank	T-310	TCEQ
ISW Storage Tank	T-320	TCEQ
ISW Storage Tank	T-330	TCEQ
ISW Storage Tank	T-340	TCEQ
ISW Storage Tank	T-350	TCEQ
ISW Storage Tank	T-360	TCEQ
ISW Storage Tank	T-370	TCEQ

APPENDICES

APPENDIX

XII-1 Itasca Industrial Waste Permit and Facility PDF

Industrial Solid Waste Permit No. 98010
EPA ID. No. TXR000085639
ISWR No. 98010

Texas Commission on Environmental Quality Austin, Texas

Permit for Industrial Solid Waste Management Site issued under provisions of Texas Health and Safety Code ANN. Chapter 361 and Chapter 26 of the Texas Water Code

Name of Permittee:	Republic Industrial and Energy Solutions, LLC 18500 North Allied Way Phoenix, Arizona 85054
Site Owner:	Republic Industrial and Energy Solutions, LLC 18500 North Allied Way Phoenix, Arizona 85054
Registered Agent for Service:	CT Corporation System 1999 Bryan Street, Suite 900 Dallas, Texas 75201

Classification of Site:

Waste Classification:	Site Type:	Permit Type:
Class 1 and Class 2 nonhazardous industrial solid waste	On-site/off-site, storage and processing	Commercial facility

The permittee is authorized to manage wastes in accordance with the limitations, requirements, and other conditions set forth herein. This permit is granted subject to the rules of the commission and other orders of the commission, and laws of the State of Texas. This permit does not exempt the permittee from compliance with the Texas Clean Air Act. This permit will be valid until canceled, amended, modified or revoked by the commission, except that the authorization to manage wastes shall expire midnight, ten (10) years after the date of this original permit approval.

Issued Date: 4/21/2022

For the Commission

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A - Legal Description of Facility
B - Facility Map
C - Permit Application Revision Chronology
D - List of Incorporated Application Materials
E - List of Permitted Facility Units

Permit Acronyms

ASTM	–	American Society for Testing and Materials
CFR	–	Code of Federal Regulations
CMP	–	Texas Coastal Management Program
EPA	–	United States Environmental Protection Agency
PCB	–	Polychlorinated Biphenyl
PCL	–	Protective Concentration Level
TAC	–	Texas Administrative Code
TCEQ	–	Texas Commission on Environmental Quality
TCEQ QAPP	–	"Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities Relating to the Resource Conservation and Recovery Act and Underground Injection Control"
TRRP	–	Texas Risk Reduction Program

I. Facility Description

A. Size and Location of Site

A permit is issued to Republic Industrial and Energy Solutions, LLC (hereafter called the permittee), to operate an industrial solid waste management facility located at 2559 FM 66, Itasca, in Hill County, Texas, and within the drainage area of Itasca Creek Segment 0814 in the Trinity River Basin (North Latitude 32° 11' 33.5", West Longitude 97° 6' 26.6"). The legal description of the facility submitted in Permit No. 98010 application dated June 17, 2021, is hereby made a part of this permit as "Attachment A." The industrial solid waste management facility as delineated by the permittee's application map is hereby made a part of this permit as "Attachment B."

B. Incorporated Application Materials

This permit is based on, and the permittee shall follow the submittals in the Permit Application to Store or Process Industrial Nonhazardous Waste and subsequent revisions to the permit and permit application that are listed in "Attachment C," and the Application Elements listed in "Attachment D," which are hereby approved subject to the terms of this permit and any other orders of the Texas Commission on Environmental Quality (TCEQ). These materials are incorporated into this permit by reference as if fully set out herein. Any and all revisions to these elements shall become conditions of this permit upon the date of approval by the commission.

II. General Facility Standards

A. Standard Permit Conditions

The permittee has a duty to comply with the Standard Permit Conditions under 30 Texas Administrative Code (TAC) Section 305.125. Moreover, the permittee has a duty to comply with the following permit conditions:

1. Modification of Permitted Facilities

   The facility units and operational methods authorized are limited to those described herein and by the application submittals identified in Section I.B. All facility units and operational methods are subject to the terms and conditions of this permit and TCEQ rules. Prior to constructing or operating any facility units in a manner which differs from either the related plans and specifications contained in the permit application or the limitations, terms or conditions of this permit, the permittee must comply with the TCEQ permit amendment/modification rules as provided in 30 TAC Sections 305.62 and 305.69.

2. Duty to Comply

   The permittee must comply with all the conditions of this permit, except that the permittee need not comply with the conditions of this permit to the extent and for the duration such noncompliance is authorized in an emergency order issued by the commission. Any permit noncompliance other than noncompliance authorized by an emergency order is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit

renewal application. [30 TAC Section 305.142]

3. Severability

   The provisions of this permit are severable. If any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected.

4. Definitions

   For purposes of this permit, terms used herein shall have the same meaning as those in 30 TAC Chapters 305, 335, and 350 unless this permit specifically provides otherwise; where terms are not defined in the regulations or the permit, the meaning associated with such terms shall be defined by a standard dictionary reference or the generally accepted scientific or industrial meaning of the term.

   Application data - data used to complete the final application and any supplemental information.

5. Permit Expiration

   In order to continue a permitted activity after the expiration date of the permit the permittee shall submit a new permit application at least 180 days before the expiration date of the effective permit, unless permission for a later date has been granted by the executive director. Authorization to continue such activity will terminate upon the effective denial of said application.

6. Certification Requirements

   For a new facility, the permittee may not commence management or processing of solid waste; and for a facility being modified, the permittee may not process or store solid waste in the modified portion of the facility, except as provided in 30 TAC Section 305.69 (relating to Solid Waste Permit Modification at the Request of the Permittee) until the following has been accomplished [30 TAC Section 305.144]:

   a. The permittee has submitted to the executive director and the local Regional Office of the TCEQ, by certified mail or hand delivery, a letter signed by the permittee, and signed, sealed, and dated by a Texas licensed professional engineer stating that the facility has been constructed or modified in compliance with the permit. Required certification shall be in the following form:

      “This is to certify that the following activity (specify activity, e.g., construction, installation, closure, etc., of an item) relating to the following item (specify the item, e.g., the particular facility, facility unit, unit component, subcomponent part, or ancillary component), authorized or required by TCEQ Permit No. 98010 has been completed, and that construction of said facility component has been performed in accordance with and in compliance with good engineering practices and the design and construction specifications of Permit No. 98010.”

b. A certification report has been submitted, with the certification described in Provision II.A.6.a., which is logically organized and describes in detail the tests, inspections, and measurements performed, their results, and all other bases for the conclusion that the facility unit, unit component, and/or closure have been constructed, installed and/or performed in conformance with the design and construction specifications of this permit and in compliance with this permit. The report shall describe each activity as it relates to each facility unit or component being certified including reference to all applicable permit provisions. The report shall contain the following items, at a minimum:

(1) Scaled, as-built plan-view and cross-sectional drawings which accurately depict the facility unit and all unit components and subcomponents, and which demonstrate compliance with the design and construction specifications approved and detailed in the terms of this permit;

(2) All necessary references to dimensions, elevations, slopes, construction materials, thickness and equipment; and

(3) For all drawings and specifications, the date, signature, and seal of a Professional Engineer who is licensed in the State of Texas.

c. The executive director has inspected the modified or newly constructed facility and finds it is in compliance with the conditions of the permit; or if within fifteen (15) days of submission of the letter required by paragraph (a) of this section, the permittee has not received notice from the executive director of the intent to inspect, prior inspection is waived and the permittee may commence processing, storage, or disposal of solid waste.

7. Land Disposal Restrictions - Reserved

8. Dust Suppression

Pursuant to 30 TAC Section 335.214(b), the permittee shall not use waste, used oil, or any other material which is contaminated with dioxin, polychlorinated biphenyls (PCBs), or any other hazardous waste (other than a waste identified solely on the basis of ignitability) for dust suppression or road treatment.

9. Permit Reopener

This permit shall be subject to review by the executive director five (5) years from the date of permit issuance or reissuance and shall be modified as necessary to assure that the facility continues to comply with currently applicable requirements of the Solid Waste Disposal Act and the rules and regulations of the commission.

10. Texas Coastal Management Program - Reserved

11. Failure to Submit Relevant Facts in Permit Application

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or any report to the executive director, the permittee shall promptly submit the

correct information or facts to the executive director. [30 TAC Section 305.125(19)]

12. Waste Management Fee Assessment, Fee Payment, and Records and Reporting

    a. If applicable, the permittee is subject to the assessment of fees for hazardous wastes which are stored, processed, disposed, or otherwise managed and for Class 1 industrial wastes which are disposed at a commercial facility. [30 TAC Section 335.325]

    b. As applicable and except as provided in Provision II.A.12.c., the permittee shall pay waste management fees monthly. Monthly fee payments shall be due by the 25th day following the end of the month for which payment is due. [30 TAC Section 335.328(b)]

    c. If required, the permittee owes waste management fees in an amount less than $500 for a calendar month or less than $1,500 for a calendar quarter, the permittee may file a quarterly report and pay a quarterly fee. [30 TAC Section 335.328(c)]

    d. If required, the permittee shall document the basis for the assessment of any applicable waste management fees, including any adjustment to or exemption from assessment. [30 TAC Section 335.329(b)(4)]

    e. If required, the permittee shall submit a monthly report of on-site waste management activities subject to the assessment of waste management fees on forms furnished or approved by the executive director. This report shall be due by the 25th day following the end of the month (or quarter) for which a report is made. Monthly (or quarterly) reports shall be submitted, regardless of whether any storage, processing, or disposal was made during a particular month (or quarter), by preparing and submitting a summary indicating that no waste was managed during that month (or quarter). [30 TAC Section 335.329(b)(5)]

    f. As applicable, the permittee shall maintain the required records and reports in accordance with 30 TAC Sections 335.329(c) and (d).

13. Transfer of Ownership and/or Operational Control

    The transfer of ownership and/or operational control of this permit is subject to the transfer requirements of 30 TAC Section 305.64 and permit modification requirements of 30 TAC Section 305.69. A permit transfer application maybe submitted as a Class 1 permit modification (with prior written approval by the executive director) in accordance with 30 TAC Section 305.69 (b)(2).

    For a permit involving nonhazardous waste only, either the transferee or the permittee shall submit to the executive director an application for permit transfer at least 30 days before the proposed transfer date [(30 TAC Section 305.64 (b)]. For a permit involving hazardous waste, the new owner and/or operator seeking a transfer of ownership and/or operational control shall submit to the executive director an application for permit transfer at least 90 days prior to the scheduled transfer [(30 TAC Section 305.64(g)]. Prior to the executive director issuing the permit modification transferring the permit, the new owner

or operator shall provide a fully executed financial assurance mechanism satisfactory to the TCEQ executive director, for all existing units which have received waste and any corrective action required under this permit, in compliance with 30 TAC Chapter 37, Subchapter P.

B. Recordkeeping and Reporting Requirements

1. Monitoring and Records

a. All data submitted to the TCEQ shall be in a manner consistent with the latest version of the "Quality Assurance Project Plan for Environmental Monitoring and Measurement Activities Relating to the Resource Conservation and Recovery Act and Underground Injection Control" (TCEQ QAPP).

b. Monitoring samples and measurements shall be taken at times and in a manner representative of the monitored activity. The method used to obtain a representative sample of the material for analysis shall be the appropriate method found in the Waste Analysis Plan of the permit application or an equivalent method approved in writing prior to use by the executive director of the TCEQ. Laboratory methods shall be the latest version specified in current edition of Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846 (EPA SW-846); Standard Methods for the Examination of Water and Wastewater; or current adopted edition; and approved in writing prior to use by the executive director. [30 TAC Section 305.125(11)(A)]

c. The permittee shall retain in an organized fashion and furnish to the executive director, upon request, records of all monitoring information, copies of all reports and records required by this permit for a period of at least three (3) years from the date of the sample, measurement, report, record, certification, or application. [30 TAC Section 305.125(11)(B)]

d. Records of monitoring shall include the following [30 TAC Section 305.125(11)(C)]:

(4) The date, time, and place of sample or measurement;

(5) The identity of individual who collected the sample or measurement;

(6) The dates analyses were performed;

(7) The identity of individual and laboratory who performed the analyses;

(8) The analytical techniques or methods used; and

(9) The results of such analyses or measurements.

e. All engineering and geoscientific information submitted to the TCEQ shall be prepared by, or under the supervision of, a licensed professional engineer or licensed professional geoscientist, and shall be signed, sealed, and dated by qualified professionals as required by the Texas Engineering

Practice Act and the Texas Geoscience Practice Act and the licensing and registration boards under these acts.

2. Operating Record

In addition to the recordkeeping and reporting requirements specified elsewhere in this permit, the permittee shall maintain a written operating record at the facility. These records will be made available to representatives of the TCEQ upon request.

3. Retention of Application Data

Throughout the terms of the permit, the permittee shall keep records of data used to complete the final application and any supplemental information. All copies of renewals, amendments, revisions and modifications must also be kept at the facility such that the most current documents are available for inspection at all times. All materials, including any related information, submitted to complete the application shall be retained, not just those materials which have been incorporated into the permit. [30 TAC Section 305.47]

4. Reporting of Noncompliance

The permittee shall report to the executive director of the TCEQ information regarding any noncompliance which may endanger human health or the environment. [30 TAC Section 305.125(9)]

a. Report of such information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the noncompliance.

b. A written submission of such information shall also be provided within five (5) days of the time the permittee becomes aware of the noncompliance. The written submission shall contain the following:

(1) A description of the noncompliance and its cause;

(2) The potential danger to human health or safety, or the environment;

(3) The period of noncompliance, including exact dates and times;

(4) If the noncompliance has not been corrected, the anticipated time it is expected to continue; and

(5) Steps taken or planned to reduce, eliminate, and prevent the recurrence of the noncompliance, and to mitigate its adverse effects.

5. Twenty-Four Hour Reporting

The following shall be included as information which must be reported orally within twenty-four (24) hours pursuant to 30 TAC Section 305.125(9) [30 TAC Section 305.145]:

a. Information concerning release of any solid waste that may cause an endangerment to public drinking water supplies; and

b. Any information of a release or discharge of solid waste, or of a fire or explosion which could threaten the environment or human health or safety, outside the facility. The description of the occurrence and its cause shall include:

(1) Name, address, and telephone number of the owner or operator;

(2) Name, address, and telephone number of the facility;

(3) Date, time, and type of incident;

(4) Name and quantity of material(s) involved;

(5) The extent of injuries, if any;

(6) An assessment of actual or potential hazards to the environment and human health or safety outside the facility, where this is applicable; and

(7) Estimated quantity and disposition of recovered material that resulted from the incident.

6. Notice Waiver

The executive director may waive the five (5) day written notice requirement specified in Provision II.B.4.b. in favor of a written report submitted to the commission within fifteen (15) days of the time the permittee becomes aware of the noncompliance or condition. [30 TAC Section 305.145(b)]

7. Pollution Prevention - Reserved

8. Annual Detection Monitoring Report - Reserved

9. Manifest Discrepancy Report

If a significant discrepancy in a manifest is discovered, the permittee must attempt to reconcile the discrepancy. If not resolved within fifteen (15) days, the permittee must submit a report, describing the incident, to the executive director, as per the requirements of 30 TAC Section 335.12. A copy of the manifest must be included in the report.

10. Unmanifested Waste Report

A report must be submitted to the executive director within fifteen (15) days of receipt of unmanifested waste, as per the requirements of 30 TAC Section 335.15(3).

11. Monthly Summary

The permittee shall prepare a monthly report, of all manifests received during the month, summarizing the quantity, character, transporter identity, and the method of storage, processing and disposal of each hazardous waste or Class 1 waste shipment received, itemized by manifest document number. This monthly summary report shall be submitted to the TCEQ Registration and Reporting

Section on or before the 25th day of each month for waste received during the previous month. [30 TAC Section 335.15(2)]

C. Incorporated Regulatory Requirements

1. State Regulations

To the extent applicable to the activities authorized by this permit, the following TCEQ regulations are hereby made provisions and conditions of the permit.

a. 30 TAC Chapter 37, Subchapter P: Financial Assurance for Hazardous and Nonhazardous Industrial Solid Waste Facilities;

b. 30 TAC Chapter 305, Subchapter A: General Provisions;

c. 30 TAC Chapter 305, Subchapter C: Application for Permit

d. 30 TAC Sections 305.61 - 305.69 (regarding amendments, renewals, transfers, corrections, revocation and suspension of permits);

e. 30 TAC Sections 305.121 - 305.125 (regarding permit characteristics and conditions);

f. 30 TAC Sections 305.127 - 305.129 (regarding permit conditions, signatories and variance procedures);

g. 30 TAC Chapter 305, Subchapter G: Additional Conditions for Hazardous and Industrial Solid Waste Storage, Processing or Disposal Permits;

h. 30 TAC Chapter 335, Subchapter A: Industrial Solid Waste and Municipal Hazardous Waste in General;

i. 30 TAC Sections 335.153 - 335.155 (regarding reporting of emergency situations and additional reports required);

j. 30 TAC Sections 335.325, 335.328 and 335.329 (regarding waste management fee assessment, fee payment, and records and reports); and

k. 30 TAC Chapter 350, Texas Risk Reduction Program.

Issuance of this permit with incorporated rules in no way exempts the permittee from compliance with any other applicable state statute and/or Commission Rule.

2. Federal Regulations - Reserved

III. Facility Management

A. Operation of Facility

The permittee shall construct, maintain, and operate the facility to minimize the possibility of a fire, explosion, or any unplanned, sudden or non-sudden release of waste constituents to air, soil, or surface water which could threaten human health

or the environment. All equipment and structures used to manage industrial solid waste at the facility shall be maintained in proper operating condition.

B. Personnel Training

The permittee shall ensure that all facility personnel involved with waste management successfully complete a training program of classroom instruction commensurate with the level of expertise required for classification of the employee. The permittee shall maintain training documents and records, as required by Section II.B.1.c.

C. Security

The permittee shall provide one of the security devices as described in the permit application.

1. The permittee shall provide a twenty-four (24) hour surveillance system which continuously monitors and controls entry onto the active portion of the facility;

2. The permittee shall provide and maintain an artificial or natural barrier which completely surrounds the active waste management portion(s) of the facility and shall have a means to control entry, at all times, through gates or other entrances to these same facility areas;

3. The permittee shall post warning signs at all points of access to the active waste management portion(s) of the facility and along the natural and/or artificial barriers in sufficient numbers to be seen from any approach to that (those) portion(s) of the facility. The signs shall be printed so that they may be clearly read from a distance of at least twenty-five (25) feet, and shall state “Danger - Unauthorized Personnel Keep Out” in English and Spanish; or

4. The permittee shall post warning signs at all points of access to the active waste management portion(s) of the facility and along the natural and/or artificial barriers in sufficient numbers to be seen from any approach to that (those) portion(s) of the facility. The signs shall be printed so that they may be clearly read from a distance of at least twenty-five (25) feet, and shall state “Danger - Unauthorized Personnel Keep Out.”

D. General Inspection Requirements

The permittee shall follow the inspection schedule contained in the permit application submittals identified in Section I.B. of this permit and as set out in Table II.- Inspection Schedule. The permittee shall remedy any deterioration or malfunction discovered by an inspection. Records of inspection shall be kept, as required by Provision II.B.2. Any remedial actions taken in response to facility inspections and the date of the remediation shall be included in the inspection records.

E. Contingency Plan

1. The permittee shall immediately initiate clean-up procedures for removal of any spilled industrial wastes and waste residues and shall take all steps necessary to prevent surface water or groundwater contamination as a result of any spills.

2. Collected industrial wastes, spills, leaks, clean-up residues, and contaminated rainfall runoff, including contaminated stormwater from the drainage control system(s) associated with the permitted units, shall be removed promptly after the spillage and/or rainfall event in as timely a manner as is necessary to prevent overflow of the system by the following method(s):

    a. Removal to an on-site authorized facility unit;

    b. Removal to an authorized industrial solid waste management facility or authorized off-site facility; or

    c. Discharge in accordance with a wastewater discharge permit.

3. The permittee shall ensure that any equipment or vehicles which have come in contact with waste in the loading/unloading, storage, processing, and/or disposal areas have been decontaminated prior to their movement into designated uncontaminated areas of the site property. At a minimum, all contaminated equipment shall be externally decontaminated and contaminated vehicles shall have their undercarriages and tires or tracks decontaminated to remove all waste residues and to prevent contamination of uncontaminated areas. All wash water generated shall be collected and disposed of in accordance with Provision III.E.2.

F. Special Permit Conditions - Reserved

IV. Wastes and Waste Analysis

A. Waste Analysis Plan

The permittee shall follow the Waste Analysis Plan, developed in permit application identified in Section I.B. of this permit.

B. Authorized Wastes

1. The permittee is authorized to manage industrial solid wastes listed in Table III.B. – Wastes Managed in Permitted Units, subject to the limitations provided herein.

2. Wastes authorized for management at the facility include those generated from facility sources and from off-site sources.

3. For wastes received from off-site sources, the permittee must inform the generator (except where the permittee is also the generator), a written notice to the generator that the permittee has the appropriate permits and will accept the waste the generator is shipping. The permittee shall keep a copy of this written notice as part of the operating record.

4. The wastes authorized in Table III.B. shall not contain any of the following:

    a. PCB waste, as defined by the Environmental Protection Agency (EPA) in regulations issued pursuant to the Toxic Substances Control Act under 40 CFR Part 761, unless the permittee is compliant with the federal requirements for PCB storage as specified in 40 CFR Part 761;

b. Radioactive materials/wastes unless the permittee is authorized to store and process these wastes in compliance with specific licensing and permitting requirements under Chapter 401 of the Texas Health and Safety Code. In accordance with 30 TAC Section 336.203, no person shall dispose of radioactive material unless that person has a license or an exemption from the TCEQ under Texas Health and Safety Code, Section 401.106(a);

c. Explosive material, as defined by the Department of Transportation under 49 CFR Part 173;

d. Dioxin-containing wastes, identified by EPA as F020, F021, F022, F023, F026, and F027 wastes in 40 CFR 261.31;

e. Ignitable compressed gases;

f. Garbage as defined in 30 TAC Section 330.3(56);

g. Municipal Solid Waste as defined in 30 TAC Section 330.3(90);

h. Putrescible Waste as defined in 30 TAC Section 330.3(122);

i. Special Waste from Health-Care Related Facilities subject to 25 TAC Part 1 or 30 TAC Chapter 330; and

j. Hazardous waste as defined in 30 TAC Chapter 335, Subchapter R.

5. Waste Acceptance Requirements

Prior to accepting any additional wastes not authorized in Table III.B., the permittee shall follow the permit amendment or modification requirements listed in 30 TAC Sections 305.62 and 305.69.

C. Sampling and Analytical Methods

1. Table III. C. – Sampling and Analytical Methods, shall be used in conjunction with the Waste Analysis Plan referenced in Section IV.A. of this permit, in performing all waste analyses.

2. The permittee shall ensure that all waste analyses utilized for waste identification or verification have been performed in accordance with methods specified in the current editions of EPA SW-846, American Society for Testing and Materials (ASTM) or other methods accepted by the TCEQ. The permittee shall have a Quality Assurance/Quality Control program that is consistent with EPA SW-846 and the TCEQ QAPP.

3. Special Permit Conditions - Reserved

V. Authorized Units and Operations

A. Authorized Units

1. The permittee is authorized to operate the permitted facility units listed in "Attachment E" for waste management subject to the limitations herein. All

waste management activities not otherwise exempted from permitting under 30 TAC Section 335.2 shall be confined to the authorized facility units subject to permitting listed in "Attachment E." References hereinafter in this permit to "TCEQ Permit Unit No____" shall be to the authorized permitted facility units listed in "Attachment E." All authorized units must be clearly identified as numbered in "Attachment E." These units must have signs indicating "TCEQ Permit Unit No.____."

2. The permittee shall prevent inundation of any permitted units and prevent any discharges of any waste or runoff of waste contaminated stormwater from permitted units. Additionally, each loading or unloading area, associated with a permitted hazardous and nonhazardous waste management unit, shall be provided with a drainage control system which will collect spills and precipitation in such a manner as to satisfy the following:

   a. Preclude the release from the system of any collected spills, leaks or precipitation;

   b. Minimize the amount of rainfall that is collected by the system; and

   c. Prevent run-on into the system from other portions of the facility.

3. The permittee shall construct, operate, and maintain the facility to prevent washout of any hazardous and nonhazardous waste by a 100-year flood, as required by 30 TAC 335.584 and as specified below:

   In the event of a 100-year flood, the permittee shall remove all nonhazardous waste, before flood waters can reach the facility, to a location where the wastes will not be vulnerable to the flood waters in accordance with the 100-year flood response procedures, specified below:

B. Container Storage Areas - Reserved

C. Tanks and Tank Systems

1. The permitted tank units and their approved waste types are shown in Table IV – Waste Management Unit Information. The permittee is authorized to operate the permitted tank units for waste management subject to the limitations contained herein.

2. The permittee shall prevent spills and overflows from the tank or containment system.

3. The permittee shall construct and maintain the containment systems for the tanks in accordance with the drawings and details included in the application materials referenced in Provision I.B.

4. Special Permit Conditions - Reserved

D. Surface Impoundments - Reserved

E. Waste Piles - Reserved

F. Land Treatment Units - Reserved

G. Landfills - Reserved

H. Incinerators - Reserved

I. Boilers/Industrial Furnaces - Reserved

J. Drip Pads - Reserved

K. Containment Buildings - Reserved

VI. Groundwater Detection Monitoring - Reserved

VII. Closure and Post-Closure Requirements

A. Facility Closure

1. The permittee shall follow the Closure Plan, developed in accordance with 30 TAC §335.8 and Chapter 350, and contained in the permit application submittals identified in Permit Provision I.B. of this permit.

   In addition, facility closure shall commence:

   a. Upon direction of the TCEQ for violation of the permit, TCEQ rules, or state statutes; or

   b. Upon suspension, cancellation, or revocation of the terms and conditions of this permit concerning the authorization to receive, store, process, or dispose of waste materials; or

   c. Upon abandonment of the site; or

   d. Upon direction of the TCEQ for failure to secure and maintain an adequate bond or other financial assurance as required by Provision VII.B.1.

2. Request for Permit Amendment or Modification

   The permittee shall submit a written request for a permit amendment or modification to authorize a change in the approved Closure Plan(s), in accordance with 30 TAC §305.62 and 305.69. The written request shall include a copy of the amended Closure Plan(s) for approval by the executive director.

3. Time Frames for Amendment/Modification Request Submittal

   The permittee shall submit a written request for a permit modification or amendment within sixty (60) days prior to a proposed change in the facility design or operation or no later than sixty (60) days after an unexpected event has occurred which has affected the closure plan. If an unexpected event occurs during the partial or final closure period, the permittee shall submit request for a permit modification or amendment no later than thirty (30) days after the unexpected event.

4. Closure Notice and Certification Requirements

   The permittee shall notify the executive director, in writing, at least forty-five (45) days prior to the date on which he expects to begin partial or final of the facility. A copy of the notice shall be submitted to the TCEQ Regional Office.

5. The permittee shall notify the TCEQ Regional Office at least ten (10) days prior to any closure sampling activity required by the permit in order to afford regional personnel the opportunity to observe these events and collect samples.

6. Unless the executive director approves an extension to the closure period, the permittee must complete partial and final closure activities within 180 days after receiving the final known volume of wastes at the waste management unit or facility.

7. Within sixty (60) days of the completion of final closure, the permittee shall submit to the executive director, by registered mail, with a copy to the TCEQ Regional Office, a certification that the waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved Closure Plan and this permit. The certification, which shall be signed by the permittee and by a Professional Engineer licensed in Texas, must be in the form described in Provision II.A.6. A closure certification report shall be submitted with the required certifications which includes a summary of the activities conducted during closure and the results of all analyses performed. The certification report shall contain the information required by Provision II.A.6. and 30 TAC §350.32 (Texas Risk Reduction Program (TRRP) Remedy Standard A). Documentation supporting the licensed Professional Engineer's certification shall be furnished to the executive director upon request until the executive director releases the permittee from the financial assurance requirements for closure under 30 TAC Chapter 37, Subchapter P and 30 TAC §335.7.

8. Final closure is considered complete when all waste management units at the facility have been closed in accordance with all applicable closure requirements so that waste management activities under 30 TAC §335.2 are no longer conducted at the facility.

9. All units, sumps, pumps, piping and any other equipment or ancillary components which have come in contact with wastes shall either be decontaminated by removing all waste, waste residues, and sludges or be disposed of in a manner authorized at this facility or at an authorized off-site facility.

10. All contaminated equipment/structures and liners (i.e., debris) intended for decontamination shall be decontaminated or removed and managed at an authorized industrial solid waste management facility.

11. All hard-surfaced areas within the waste management unit areas shall be decontaminated and the wash water generated treated and/or disposed in a manner authorized at this facility or at an authorized off-site facility.

12. Verification of decontamination shall be performed by analyzing wash water, and as necessary, soil samples for the hazardous constituents which have been

in contact with the particular item being decontaminated. In addition, the permittee shall perform visual inspections of the equipment/structures for visible evidence of contamination.

13. Unless it can be demonstrated that soil contamination has not occurred, soils shall be sampled and analyzed. Sufficiently detailed analyses of samples representative of soils remaining in non-hard-surfaced areas of the storage and processing facility area shall be performed to verify removal or decontamination of all waste and waste residues.

14. Soil and/or wash water samples shall be analyzed using laboratory methods specified in Provision II.B.1.b. Equivalent or modified methods must be specified in the Closure Plan and have written approval of the executive director prior to use. All data submitted to the TCEQ shall be in a manner consistent with the latest version of the TCEQ QAPP.

15. Decontamination shall be deemed complete when no visible evidence of contamination is observed and when the results from verification sampling and analyses indicate wash water and soil meet the following criteria:

    a. Decontamination of hard-surfaced areas used for waste management (such as tank interiors, secondary containment structures, ancillary equipment, sumps, loading/unloading docks, etc.) shall be deemed complete when the concentration of each chemical of concern in the final rinsate sample(s) collected from the wash water is below TRRP Remedy Standard A, Tier 1 Residential Class 1 Groundwater PCL; and

    b. Unless it can be demonstrated that soil contamination has not occurred, underlying soils shall be decontaminated or removed to the TRRP Remedy Standard A, Residential PCL, for no further action. If the underlying soils are decontaminated or removed to the PCL for Remedy Standard A, Commercial/Industrial Land use, the permittee shall comply with the institutional controls requirements of 30 TAC Section 350.111, as required.

B. Financial Assurance for Closure

1. The permittee shall provide financial assurance for closure of all existing permitted units covered by this permit in an amount not less than $41,437 (2021 dollars) for proposed units as shown on Table VII.C. - Permitted Unit Closure Cost Summary. Financial assurance shall be secured and maintained in compliance with 30 TAC Chapter 37, Subchapter P; and 30 TAC Section 335.179. Financial assurance is subject to the following:

    a. Adjustments to Financial Assurance Amount

        (1) At least sixty (60) days prior to acceptance of waste in proposed permitted units listed in Table VII.C. - Permitted Unit Closure Cost Summary, the permittee shall increase the amount of financial assurance required for closure by the amounts listed in Table VII.C. and shall submit additional financial assurance documentation

        (2) The amount of financial assurance for closure of existing units, may be reduced by the amount listed in Table VII.C., upon certification of closure

of an existing permitted unit, in accordance with Provisions VII.A.4. and VII.A.6., and upon written approval of the executive director.

b. Annual Inflation Adjustments

5. The permittee shall submit to the executive director, upon request, such information as may be required to determine the adequacy of the financial assurance.

C. Storage, Processing, and Combustion Unit Closure Requirements

The permittee shall close the tank units identified in Table IV in accordance with the approved Closure Plan and the TRRP in 30 TAC Chapter 350 and the following requirements.

If all contaminated soils cannot be removed or decontaminated to TRRP Remedy Standard A, and the permittee or the executive director determines that the tank units must be closed as a landfill, within ninety (90) days, the permittee shall submit a permit modification request incorporating a revised closure and post-closure plan. to close the units as a landfill and perform post-closure care. [30 TAC Section 305.69 and Chapter 350, Subchapter B]

D. Surface Impoundment Closure Requirements - Reserved

E. Landfill Closure and Certification Requirements - Reserved

F. Containment Buildings Closure Requirements - Reserved

G. Facility Post-Closure Care Requirements - Reserved

H. Financial Assurance for Post-Closure - Reserved

VIII. Liability Requirements

A. Sudden Accidental Occurrences

The permittee shall maintain liability coverage for sudden accidental occurrences of at least $1 million per occurrence, with an annual aggregate of at least $2 million, exclusive of legal defense costs.

B. Incapacity of Owners or Operators, Guarantors, or Financial Institutions

The permittee shall comply with 30 TAC Section 37.71, regarding bankruptcy, whenever necessary.

IX. Corrective Action for Solid Waste Management Units - Reserved

X. Air Emission Standards

Emissions from this facility must not cause or contribute to a condition of “air pollution” as defined in Section 382.003 of the Texas Health and Safety Code Ann. or violate Section 382.085 of the Texas Health and Safety Code Ann. If the executive director of the TCEQ determines that such a condition or violation occurs, the permittee

shall implement additional abatement measures as necessary to control or prevent the condition or violation.

XI. Compliance Plan - Reserved

Table II. - Inspection Schedule

Facility Unit(s) and Basic Elements	Possible Error, Malfunction, or Deterioration	Frequency of Inspection
DAILY		
Tank	Spills or releases of tank due to overflow, improper operation, or loss of tank integrity. Tank will be inspected after a storm for possible cracks and ponding.	Per schedule below and following a storm.
Tank	– temperature gauge	Daily
Tank	– level gauge	Daily
Tank	– tank corrosion	Daily external visual
Tank	– valve corrosion	Daily visual
Tank	– valve operability	Daily
Tank	– obvious tank corrosion	Daily external visual
Tank	– detailed integrity testing	Daily
Tank	– secondary containment and system integrity	Daily visual and post storm
WEEKLY		
Pumps	– Operability	Weekly
Fire Extinguishers	– Visual inspection	Weekly
Safety Equipment	– Adequate inventory, condition	Weekly
First Aid Kit/Eye & Skin Neutralizer	– Completeness, inventory	Weekly
Safety Shower/Eyewash	– Operability	Weekly
MONTHLY		
Unloading Bays	– Structure Conditions and Integrity	Monthly visual
Unloading Bays	– cracks	Monthly visual
Unloading Bays	– ponded water	Monthly visual
Fire Hoses	– Physical integrity	Monthly
Foam Equipment	– Operability	Monthly
Spill Control	– Adequate inventory, condition after significant spill or leak	Monthly
Decontamination Chemicals	– Inventory	Monthly
YEARLY		
Tank	– pressure device	Yearly

Table III.B. - Wastes Managed In Permitted Units

No.	Waste	Physical Form (e.g., solid, liquid, sludge)	TCEQ Waste Form Codes and Classification Codes
1	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	205-1
2	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Sludge	504-1
3	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	101-1
4	Aqueous organic wastes	Liquid	102-1
5	Aqueous metallic wastes	Liquid	103-1
6	Aqueous acid wastes	Liquid	105-1
7	Aqueous caustic wastes	Liquid	110-1
8	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	113-1
9	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	114-1
10	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	115-1
11	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	119-1
12	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	199-1
13	Other associated wastes compatible with the permitted waste streams	Sludge	603-1
14	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	205-2
15	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Sludge	504-2

16	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	101-2
17	Aqueous organic wastes	Liquid	102-2
18	Aqueous metallic wastes	Liquid	103-2
19	Aqueous acid wastes	Liquid	105-2
20	Aqueous caustic wastes	Liquid	113-2
21	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	114-2
22	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	115-2
23	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	119-2
24	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	199-2
25	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	116-1
26	Aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	219-1
27	Concentrated aqueous solution of other organics that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	207-1
28	Leachate aqueous solutions that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	116-2
29	Other organic liquids that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	219-2
30	Concentrated aqueous solution of other organics that contain contaminants below the regulatory limits set forth in 40 CFR 261.24, Table 1	Liquid	207-2

Table III.C - Sampling and Analytical Methods

Waste No.[1]	Sampling Location	Sampling Method	Frequency	Parameter	Test Method
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	From container (as received from generator) or tanker	Coliwasa or other appropriate sampling methods	At least annually or as requested by disposal facility	Can be process knowledge from profile or Safety Data Sheet (SDS) and/or pH, ignitability, TCLP Metals, Volatiles, Semi-Volatiles	Metals 6020, 7470 Volatiles 8260 Semi-Volatiles 8270 Ignitability SW 846 Corrosivity 9040, 9045

[1]from first column of Table III.B.

Table IV – Waste Management Unit Information

Permit Unit No.	Waste Management Unit	TCEQ N.O.R. No.	Waste Nos.[1] Managed in Unit	Function(s) of Unit (storage/ processing)	Rated Capacity of Unit
T-300	Tank	001	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30	Storage	31,500 gal
T-310	Tank	002	See T-300	Storage	31,500 gal
T-320	Tank	003	See T-300	Storage	31,500 gal
T-330	Tank	004	See T-300	Storage	31,500 gal
T-340	Tank	005	See T-300	Storage	31,500 gal
T-350	Tank	006	See T-300	Storage	31,500 gal
T-360	Tank	007	See T-300	Storage	31,500 gal
T-370	Tank	008	See T-300	Storage	31,500 gal
T-260	Product Tank	009	Product Only	Product Storage	12,500 gal
SC-100	Secondary Containment Sump	010	See T-300	Spill Containment	480 gal
UB-100	Unloading Bay	011	See T-300	Spill Containment	3,680 gal
UB-110	Unloading Bay	012	See T-300	Spill Containment	3,680 gal

[1]from first column of Table III.B.

Table VII.C - Permitted Unit Closure Cost Summary

Existing Unit Closure Cost Estimate

Unit	Cost
NOT APPLICABLE	

Total Existing Unit Closure Cost Estimate (20__) dollars

Proposed Unit Closure Cost Estimate

Unit	Cost
All Units[1,2]	$41,437
Total Proposed Units Closure Cost Estimate	**$41,437**

Total Existing Unit Closure Cost Estimate (2021 dollars)

1 As units are added or deleted from these tables through future permit amendments or modifications, additional closure costs will be added. The closure costs shown will be updated annually for inflation using factors provided by TCEQ. The total costs shown above reflect 2021 costs based on the assumptions detailed in Table VII.B and include a 10% contingency as defined in TCEQ Technical Guidance Document 10.

2 See Table VII.B (Unit Closure Cost Estimate) of the application for a breakdown of costs.

ISW 98010
Republic Industrial and Energy Solutions, LLC

Attachmment A

METES & BOUNDS DESCRIPTION

BEING a 3.428–acre tract situated in the ORLANDO WHEELER SURVEY, ABSTRACT No. 940, Hunt County, Texas, and being a portion of that certain 360.451 acre tract conveyed to Itasca Landfill TX, LP as described as "Parcel 1" in Volume 1155, Page 257 in the Deed Records of Hill County, Texas, (D.R.H.C.T.) and recorded on March 14, 2002, said 3.428–acre tract being more particularly described as follows:

COMMENCING at a 7/8–inch pipe found in the northwesterly line of said 360.451–acre tract and being the southwest corner of a called 65.307–acre tract conveyed to said Itasca Landfill TX, LP and described as "Parcel 2" in said Volume 1155, Page 257 (D.R.H.C.T.), having local site coordinates of N: 191,262.85, E: 2,119,698.93, and from which a 60 penny nail found in said northwesterly line of said 360.451–acre tract bears South 60 degrees 56 minutes 55 seconds West, 1,568.90 feet (called North 60 degrees 57 minutes 23 seconds East, 1,568.49 feet);

THENCE North 61 degrees 01 minutes 08 seconds East (called North 60 degrees 59 minutes 46 seconds East) with the common line of said 360.451–acre and said 65.607–acre tracts, 1,669.39 feet to a point;

THENCE South 28 degrees 58 minutes 52 seconds East, projecting into said 360.451–acre tract, 110.34 feet to a point for the POINT OF BEGINNING of the hereinafter described tract and having local site coordinates of N: 191,975.19, E: 2,121,212.75:

THENCE (L2) North 66 degrees 43 minutes 17 seconds East, 300.00 feet to a point, from which a 1/2–inch rebar set for reference bears North 44 degrees 26 minutes 22 seconds East, 202.83 feet;

THENCE (L3) South 23 degrees 16 minutes 43 seconds East, 300.00 feet to a point;

THENCE (L4) South 11 degrees 43 minutes 12 seconds West, 114.39 feet to a point;

THENCE (L5) South 12 degrees 04 minutes 29 seconds East, 185.00 feet to a point, from which a 1/2–inch rebar set for reference bears South 74 degrees 57 minutes 00 seconds East, 546.07 feet;

THENCE (L6) South 35 degrees 39 minutes 02 seconds West, 161.98 feet to a point;

THENCE (L7) South 17 degrees 42 minutes 50 seconds West, 90.00 feet to a point;

THENCE (L8) North 72 degrees 17 minutes 10 seconds West, 114.00 feet to a point, from which a 1/2–inch rebar set for reference bears South 7 degrees 19 minutes 57 seconds West, 190.40 feet;

THENCE (L9) North 17 degrees 42 minutes 50 seconds East, 90.00 feet to a point;

THENCE (L10) North 44 degrees 20 minutes 14 seconds East, 171.41 feet to a point;

THENCE (L11) North 12 degrees 04 minutes 29 seconds West, 80.00 feet to a point;

THENCE (L12) North 69 degrees 45 minutes 38 seconds West, 203.67 feet to a point;

THENCE (L13) North 23 degrees 16 minutes 43 seconds West, 300.00 feet to the POINT OF BEGINNING, containing 3.428–acres or 149,324 square feet of land, more or less.

Line Table		
Line #	Bearing	Distance
L1	S28° 58' 52"E	110.34
L2	N66° 43' 17"E	300.00
L3	S23° 16' 43"E	300.00
L4	S11° 43' 12"W	114.39
L5	S12° 04' 29"E	185.00
L6	S35° 39' 02"W	161.98
L7	S17° 42' 50"W	90.00
L8	N72° 17' 10"W	114.00
L9	N17° 42' 50"E	90.00
L10	N44° 20' 14"E	171.41
L11	N12° 04' 29"W	80.00
L12	N69° 45' 38"W	203.67
L13	N23° 16' 43"W	300.00

SURVEY NOTES

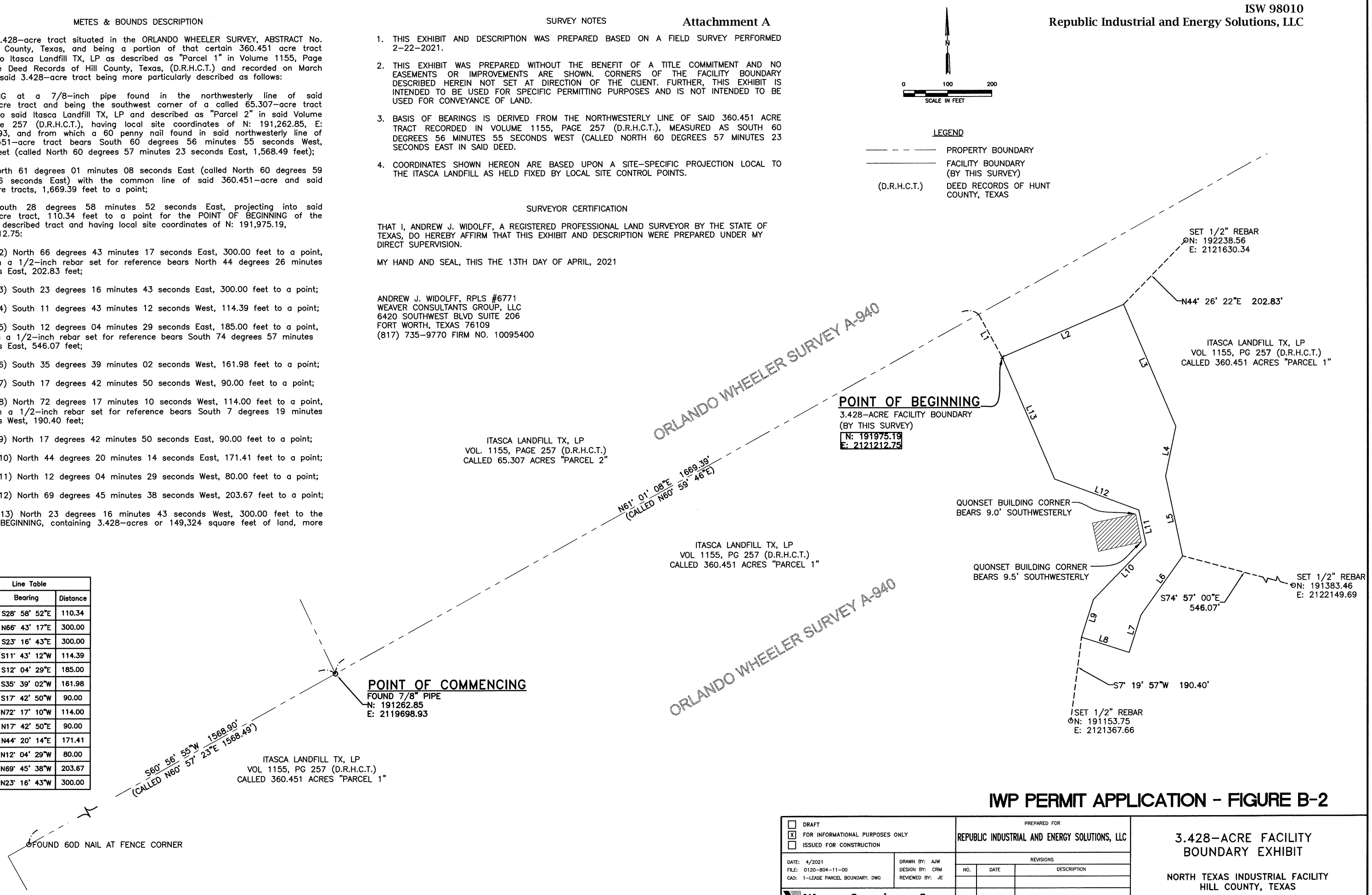
1. THIS EXHIBIT AND DESCRIPTION WAS PREPARED BASED ON A FIELD SURVEY PERFORMED 2–22–2021.
2. THIS EXHIBIT WAS PREPARED WITHOUT THE BENEFIT OF A TITLE COMMITMENT AND NO EASEMENTS OR IMPROVEMENTS ARE SHOWN. CORNERS OF THE FACILITY BOUNDARY DESCRIBED HEREIN NOT SET AT DIRECTION OF THE CLIENT. FURTHER, THIS EXHIBIT IS INTENDED TO BE USED FOR SPECIFIC PERMITTING PURPOSES AND IS NOT INTENDED TO BE USED FOR CONVEYANCE OF LAND.
3. BASIS OF BEARINGS IS DERIVED FROM THE NORTHWESTERLY LINE OF SAID 360.451 ACRE TRACT RECORDED IN VOLUME 1155, PAGE 257 (D.R.H.C.T.), MEASURED AS SOUTH 60 DEGREES 56 MINUTES 55 SECONDS WEST (CALLED NORTH 60 DEGREES 57 MINUTES 23 SECONDS EAST IN SAID DEED.
4. COORDINATES SHOWN HEREON ARE BASED UPON A SITE–SPECIFIC PROJECTION LOCAL TO THE ITASCA LANDFILL AS HELD FIXED BY LOCAL SITE CONTROL POINTS.

SURVEYOR CERTIFICATION

THAT I, ANDREW J. WIDOLFF, A REGISTERED PROFESSIONAL LAND SURVEYOR BY THE STATE OF TEXAS, DO HEREBY AFFIRM THAT THIS EXHIBIT AND DESCRIPTION WERE PREPARED UNDER MY DIRECT SUPERVISION.

MY HAND AND SEAL, THIS THE 13TH DAY OF APRIL, 2021

ANDREW J. WIDOLFF, RPLS #6771
WEAVER CONSULTANTS GROUP, LLC
6420 SOUTHWEST BLVD SUITE 206
FORT WORTH, TEXAS 76109
(817) 735–9770 FIRM NO. 10095400



IWP PERMIT APPLICATION - FIGURE B-2

☐ DRAFT
☒ FOR INFORMATIONAL PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 4/2021
FILE: 0120–804–11–00
CAD: 1–LEASE PARCEL BOUNDARY. DWG

DRAWN BY: AJW
DESIGN BY: CRM
REVIEWED BY: JE

Weaver Consultants Group
TBPELS ENG. FIRM NO. F–3727
TBPELS SURV. FIRM NO. 10095400

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

3.428–ACRE FACILITY BOUNDARY EXHIBIT

NORTH TEXAS INDUSTRIAL FACILITY
HILL COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING 1

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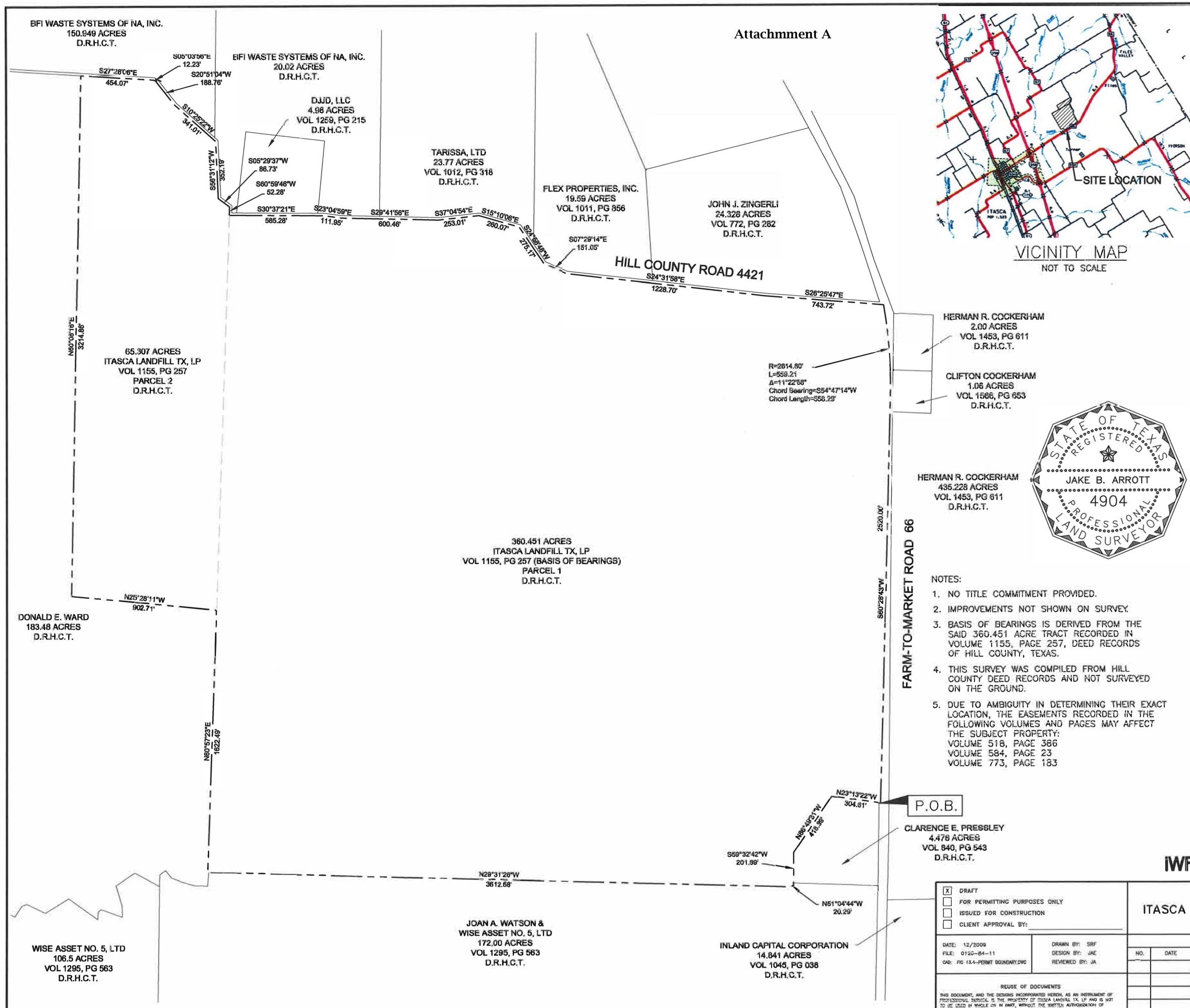
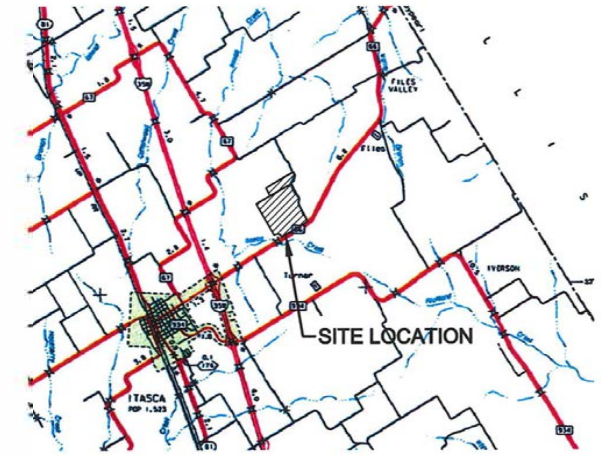
P:\SBI Survey\Solid Waste\0120 (Allied)\804 (Itasca-Tervita Deep Well Site)\0120-804-11-00 (Deep Well Lease Boundary)\2.0 Drawings\2.1 CAD\1-LEASE PARCEL BOUNDARY.dwg, rarrington, 1:2

ISW 98010
Republic Industrial and Energy Solutions, LLC





VICINITY MAP
NOT TO SCALE

0 300 600
SCALE IN FEET

LEGEND
PERMIT BOUNDARY

STATE OF TEXAS REGISTERED
JAKE B. ARROTT
4904
PROFESSIONAL LAND SURVEYOR

NOTES:

1. NO TITLE COMMITMENT PROVIDED.
2. IMPROVEMENTS NOT SHOWN ON SURVEY.
3. BASIS OF BEARINGS IS DERIVED FROM THE SAID 360.451 ACRE TRACT RECORDED IN VOLUME 1155, PAGE 257, DEED RECORDS OF HILL COUNTY, TEXAS.
4. THIS SURVEY WAS COMPILED FROM HILL COUNTY DEED RECORDS AND NOT SURVEYED ON THE GROUND.
5. DUE TO AMBIGUITY IN DETERMINING THEIR EXACT LOCATION, THE EASEMENTS RECORDED IN THE FOLLOWING VOLUMES AND PAGES MAY AFFECT THE SUBJECT PROPERTY:
   VOLUME 518, PAGE 386
   VOLUME 584, PAGE 23
   VOLUME 773, PAGE 183

METES AND BOUNDS DESCRIPTION

BEING a 425.758 acre tract situated in the ORLANDO WHEELER SURVEY, ABSTRACT No. 940, and being all of that certain 65.307 acre tract conveyed to Itasca Landfill TX, LP as recorded in Volume 1155, Page 257 of the Deed Records of Hill County, Texas, and being all of that certain 360.451 acre tract conveyed to Itasca Landfill TX, LP as recorded in Volume 1155, Page 257 of the Deed Records of Hill County, Texas, and being more particularly described by metes and bounds as follows:

BEGINNING at the southeast corner of that certain tract of land deeded to Clarence E. and wife Susie Pressley as recorded in Volume 840, Page 543 of the said deed records and being a corner of the said 360.451 acre tract, said point also being in the northwest line of Farm-to-Market Road 66;

THENCE along the boundary lines of the said 360.451 acre tract the following bearings and distances:
N 23°13'22" W, 304.61 feet;
N 86°49'31" W, 418.39 feet;
S 59°32'42" W, 201.89 feet;
N 51°04'44" W, 20.29 feet;
N 29°31'26" W, 3612.68 feet;
N 60°57'23" E, 1622.49 feet;

THENCE along the boundary lines of the said 65.307 acre tract the following bearings and distances:
N 25°28'11" W, 902.71 feet;
N 60°08'16" E, 3214.86 feet;
S 27°28'06" E, 454.07 feet;
S 05°03'56" W, 12.23 feet;
S 20°51'04" W, 188.76 feet;
S 10°25'22" W, 341.01 feet;
S 56°31'12" W, 352.19 feet;
S 05°29'37" W, 86.73 feet;
S 60°59'46" W, 52.28 feet;

THENCE along the boundary lines of the said 360.451 acre tract the following bearings and distances:
S 30°37'21" W, 585.28 feet;
S 23°04'59" E, 111.95 feet;
S 29°41'56" E, 600.46 feet;
S 37°04'54" E, 253.01 feet;
S 15°10'06" E, 260.07 feet;
S 24°58'48" W, 275.17 feet;
S 07°29'14" E, 151.05 feet;
S 24°31'58" E, 1228.70 feet;
S 26°25'47" E, 743.72 feet to the beginning of a non-tangent curve to the right;

THENCE 559.21 feet along the said curve to the right having a radius of 2814.80 feet, a central angle of 11°22'58", and a long chord which bears S 54°47'14" W, a distance of 558.29 feet;

THENCE S 60°28'43" W, 2520.00 feet to the POINT OF BEGINNING and containing 425.758 acres of land.

IWP PERMIT APPLICATION - FIGURE B-1

- [X] DRAFT
- [ ] FOR PERMITTING PURPOSES ONLY
- [ ] ISSUED FOR CONSTRUCTION
- [ ] CLIENT APPROVAL BY:

DATE: 12/2009
FILE: 0120-84-11
CAD: FIG 13.4-PERMIT BOUNDARY.DWG

DRAWN BY: SRF
DESIGN BY: JAE
REVIEWED BY: JA

PREPARED FOR
ITASCA LANDFILL TX, LP

REVISIONS

NO.	DATE	DESCRIPTION

MAJOR PERMIT AMENDMENT

PERMIT BOUNDARY SURVEY
ITASCA LANDFILL
HILL COUNTY, TEXAS

Weaver Boos Consultants
TBPE REGISTRATION NO. F-3727

CHICAGO, IL
NAPERVILLE, IL
COLUMBUS, OH
DENVER, CO
FORT WORTH, TX (817) 735-9770
GRIFFITH, IN
SOUTHBEND, IN
SPRINGFIELD, IL
ST. LOUIS, MO

FIGURE I/II - 13.4

REUSE OF DOCUMENTS
THIS DOCUMENT, AND THE DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF ITASCA LANDFILL TX, LP AND IS NOT TO BE USED IN WHOLE OR IN PART, WITHOUT THE WRITTEN AUTHORIZATION OF ITASCA LANDFILL TX, LP.

COPYRIGHT © 2009 ITASCA LANDFILL TX, LP. ALL RIGHTS RESERVED.

O:\0120\84\EXPANSION (2008)\PARTS I-II\Fig 13.4-Permit Boundary.dwg, rarrington, 1:2

002124

SPECIAL WARRANTY DEED

THE STATE OF TEXAS)
) KNOW ALL BY THESE PRESENTS:
COUNTY OF HILL)

THAT THE UNDERSIGNED, **BFI Waste Systems of North America, Inc.**, a Delaware corporation, as successor by merger to Browning-Ferris, Inc., hereinafter referred to as "GRANTOR", whether one or more, for and in consideration of the sum of TEN DOLLARS ($10.00) cash, and other good and valuable consideration in hand paid by the Grantee, herein named, the receipt and sufficiency of which is hereby fully acknowledged and confessed, has GRANTED, SOLD and CONVEYED, and by these presents does hereby GRANT, SELL and CONVEY unto **Itasca Landfill TX, LP**, a Texas Limited Partnership, herein referred to as "GRANTEE", whether one or more, the real property described as follows:

See Exhibit "A" attached hereto and made a part hereof

This conveyance, however, is made and accepted subject to any and all validly existing encumbrances, conditions and restrictions, relating to the hereinabove described property as now reflected by the records of the County Clerk of Hill County, Texas.

TO HAVE AND TO HOLD the above described premises, together with all and singular the rights and appurtenances thereto in anywise belonging unto the said GRANTEE, GRANTEE'S heirs, executors, administrators, successors and/or assigns forever, and GRANTOR does hereby bind GRANTOR'S heirs, executors, administrators, successors and/or assigns, to WARRANT AND FOREVER DEFEND all and singular the said premises unto the said GRANTEE, GRANTEE'S heirs, executors, administrators, successors and/or assigns, against every person whomsoever lawfully claiming or to claim the same or any part thereof, except as to the reservations from and exceptions to conveyance and warranty, when the claim is by, through or under Grantor, but not otherwise.

Current ad valorem taxes on said property having been prorated, the payment thereof is assumed by GRANTEE.

EXECUTED this 31st day of December, 2001.

BFI Waste Systems of North America, Inc.

BY: _____
Jo Lynn White, Secretary

THE STATE OF ARIZONA)
)
COUNTY OF MARICOPA)

This instrument was acknowledged before me on this the 31st day of December, 2001 by Jo Lynn White, as Secretary, of BFI Waste Systems of North America, Inc.

"OFFICIAL SEAL"
Catherine Childress
Notary Public-Arizona
Maricopa County
My Commission Expires 6/29/2004

_____
NOTARY PUBLIC IN AND FOR THE STATE OF ARIZONA

MY COMMISSION EXPIRES:

_____

AFTER RECORDING RETURN TO:

Eileen B. Schuler
BFI Waste Systems of North America, Inc.
757 N. Eldridge, Suite 448
Houston, TX 77079

Parcel 1:

PROPERTY DESCRIPTION

360.451 Acres of land situated in the Orlander Wheeler Survey, Abstract No. 940, Hill County, Texas; said 360.451 acres of land being a portion of that called 360.973 acre tract of land conveyed to Browning-Ferris, Inc. as recorded in Volume 753, Page 89, Deed Records of Hill County, Texas; said 360.451 acres of land being more particularly described by metes and bound as follows:

Beginning at a 1/2 inch iron rod found in the northwesterly Row line of Farm to Market Highway No. 66 at the most southerly southwest corner of said Browning-Ferris, Inc. tract; said iron rod also being the southeast corner of a tract of land conveyed to Clarence E. Pressley and wife Susie Pressley as recorded in Volume 840, Page 543, Deed Records of Hill County, Texas, said iron rod being futher described having Texas State Plane Coordinate System, North Central Zone, NAD, 1927 coordinates of X=2,120,788.81 and Y=187,117.16. The coordinates are based upon Triangulation Station "FILES", Itasca, Hill County, Texas. The combined scale factor used to determine the coordinates is 0.999949438. The bearings are State Plane bearings.

THENCE N 23° 13' 22" W, 304.61 feet (deed N 24° 00' W, 304.67) feet along the common line of said Browning-Ferris, Inc. and said Pressley tract to a 1/2 inch iron rod found ;

THENCE N 86° 49' 31" W, 418.39 feet (deed N 88° 00' W, 419.05 feet) continuing along said common line to a 1/2 inch iron rod found near a fence corner;

THENCE S 59° 32' 42" W, 201.89 feet (deed S 58° 35' W, 202.50 feet) continuing along said common line to a 1/2 inch iron rod found near a fence corner, said iron rod being the northwest corner of said Pressley tract;

THENCE N 51° 04' 44" W, 20.29 feet (deed N 51° 38' W, 20.00 feet along a fence line and continuing along the west line of said Browning-Ferris, Inc. tract to a 1/2 inch iron rod found at an angle point in said fence line;

THENCE N 29° 31' 26" W, (deed N 30° 33' W) at 188.2 feet pass a point which is 6.6 feet easterly from a fence corner post which said fence runs southerly and westerly and continuing along the west line of said Browning-Ferris, Inc. tract in all 3,612.68 feet (deed 3613.50 feet) to the northwest corner of said Browning-Ferris, Inc. tract in a creek;

THENCE N 60° 57' 23" E, (deed N 59° 57' W) at 54.00 feet pass a 1/2 inch iron rod found on the east bank of said creek near a fence corner and continuing along the northerly line of said Browning-Ferris, Inc. tract and near a fence line 1622.49 feet to a 3/4 inch iron pipe found at a fence corner, said pipe being the southwest corner of a tract of land conveyed to Browning-Ferris, Inc. as recorded in Volume 829, Page 373, Deed Records of Hill County, Texas;

THENCE N 60° 59' 46" E, (deed N 59° 57' W) 2,439.63 feet along the common line of the two Browning-Ferris, Inc. tracts and generally along a fence line to a 1/2 inch iron rod set with plastic cap stamped "Landes & Assoc." at the northwest corner of a tract of land conveyed to The Veterans Land Board of the State of Texas as recorded in Volume 558, Page 571, Deed Records Hill County Texas;

Parcel 1 Continued:

THENCE S 30° 37' 21" E, 585.28 feet along the westerly line of said Land Board tract to an angle point in a gravel county road and in the easterly line of said Browning-Ferris, Inc. tract from which a 1/2 inch iron rod set marked as before bears S 05° 30' 30" E, 77.80 feet;

THENCE S 23° 04' 59" E (deed S 24° 10' E), 111.95 feet continuing along said road to an angle point from which an iron rod set marked as before bears S 05° 06' 06" E, 61.79 feet;

THENCE S 29° 41' 56" E, 600.46 feet (deed S 30° 47' E, 600.40 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod marked as before bears S 13° 23' 06" E, 94.28 feet;

THENCE S 37° 04' 54" E, 253.01 feet (deed S 38° 10' E, 253.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod bears S 88° 03' 43" W, 51.26 feet;

THENCE S 15° 10' 06" E, 260.07 feet (deed S 16° 15' E, 260.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bears N 44° 55' 52" W, 63.82 feet;

THENCE S 24° 58' 48" W, 275.17 feet (deed S 23° 55' W, 275.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bearing S 78° 10" 38" W, 33.61 feet;

THENCE S 07° 29' 14" E, 151.05 feet (deed S 08° 34' W, 151.00 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set marked as before bears S 88° 45' 42" W, 34.01 feet;

THENCE S 24° 31' 58" E, 1228.70 feet (deed S 25° 37' E, 1228.50 feet) continuing along said county road to an angle point from which a 1/2 inch iron rod set, marked as before bears S 27° 13' 45" W, 37.67 feet;

THENCE S 26° 25' 47" E, 743.72 feet (deed S 27° 31' E, 744.10 feet) continuing along said county road to the southeast corner of said Browning-Ferris, Inc. tract, said corner being in the northerly ROW line of the aforementioned F.M. Hwy. No. 66 from said corner, a 1/2 inch iron rod found bears S 48° 48' 49" W, 19.99 feet; said corner also being in a nontangent curve to the right whose radius is 2814.80 feet and whose long chord bears S 54° 47' 14" W, 558.29 feet (deed S 53° 45' 01" W, 558.29 feet);

THENCE along the southerly line of said Browning-Ferris, Inc. tract and along said northerly ROW line and along said curve to the right in a southwesterly direction through a central angle of 11° 22' 58" an arc length of 559.21 feet to a 1/2 inch iron rod found at the end of said curve, said iron rod being 5.6 feet southerly from a wire fence;

THENCE S 60° 28' 43" (deed S 59° 26' 30" W), 2,520.00 feet continuing along said southerly line of said Browning-Ferris, Inc. tract and along said highway ROW line to the POINT OF BEGINNING and containing 360.451 acres of land of which 2.558 acres of land lies within said county road running along the easterly side of said 360.451 acre tract.

Parcel 2:

65.307 acres of land situated in the Orlando Wheeler Survey, Abstract No. 949, Hill County, Texas, said 65.307 acres of land being a portion of a certain 66.359 acre tract described in a Lease Agreement to Browning Ferris, Inc. and recorded in Volume 645, Page 553, Hill County Deed Records, said 65.307 acres of land being more particularly described by metes and bounds as follows:

BEGINNING at a 5/8 inch iron rod found in the westerly ROW line and fence line of a gravel county road, said iron rod bears S 59° 57' W from an iron rod found in said county road, the southerly most southeast corner of said 66.359 acre lease tract;

THENCE S 59° 57' W 2491.91 feet along the southerly line of said lease tract to a 1" iron pipe found at the southwest corner of said lease tract;

THENCE N 26° 30' 57" W 902.71 feet along a fence line and along the west line of said least tract to a 1 3/4 inch iron pipe found S 26° 30' 57" E 37.4 feet from a fence corner;

THENCE N 59° 05' 30" E along the northerly line of said lease tract at approximatley 1080 feet passing near a fence angle point and continuing along and near a fence line in all 3214.86 feet to a 1/2 inch iron rod found at a fence corner once again in the westerly ROW line of the aforementioned county road, said iron rod bears S 59° 05' 30" W 26.0 feet from an iron rod in said county road, the northeast corner of said lease tract;

THENCE along said westerly ROW line and said westerly fence line of said county road the following courses and distances:

S 28° 30' 52" E 454.07 feet;

S 06 06' 42" E 12.23 feet;

S 19° 48' 18" W 188.76 feet;

S 09° 22' 36" W 341.01 feet;

S 55° 28" 26" W 352.19 feet;

S 04° 26' 51" W 86.73 feet to the POINT OF BEGINNING and containing 65.307 acres of land being all of the 66.359 acre lease tract previously mentioned above excluding 1.052 acres of land lying within the county road which had been included in said lease tract.

OFF REC 1155 PAGE 0260

002124

FILED
AT 2:58 O'CLOCK P M
ON THE 14 DAY OF March
A.D., 20 02

Ruth Pelham
COUNTY CLERK, HILL CO. TEXAS

BY Sue McClure
DEPUTY

STATE OF TEXAS
COUNTY OF HILL
I hereby certify that this instrument was FILED on the date and at the time stamped hereon by me and was duly RECORDED in the Volume and Page of the Official Public Records of Hill County, Texas.

Ruth Pelham
County Clerk, Hill County, Texas

BY J. Hilton DEPUTY

RECORDED 3-14-2002

Return to:
Stewart Title Int'l Marketing
1980 Post Oak BLVD Ste. 610
Houston, TX. 77056

OFF REC 1155 PAGE 0261

Attachment B

0 300 600
SCALE IN FEET

LEGEND

- ITASCA LANDFILL PERMIT BOUNDARY (TCEQ PERMIT NO. MSW-241D)
- NORTH TEXAS INDUSTRIAL FACILITY PERMIT PROPERTY BOUNDARY
- ITASCA LANDFILL PERMITTED LIMITS OF WASTE
- 730 — EXISTING CONTOUR
- N 188000 — STATE PLANE COORDINATE GRID

NOTES:

1. EXISTING CONTOURS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY, FLOWN 01-21-2021.

STATE OF TEXAS
DAVID E. POE
81734
LICENSED
PROFESSIONAL ENGINEER
06/17/21

- ☐ DRAFT
- ☒ ISSUED FOR PERMITTING PURPOSES
- ☐ FOR BIDDING PURPOSES ONLY

DATE: 06/2021
FILE: 0120-084-10
CAD: D-2-SITE PLAN.DWG

DRAWN BY: RAA
DESIGN BY: JBM
REVIEWED BY: DP

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

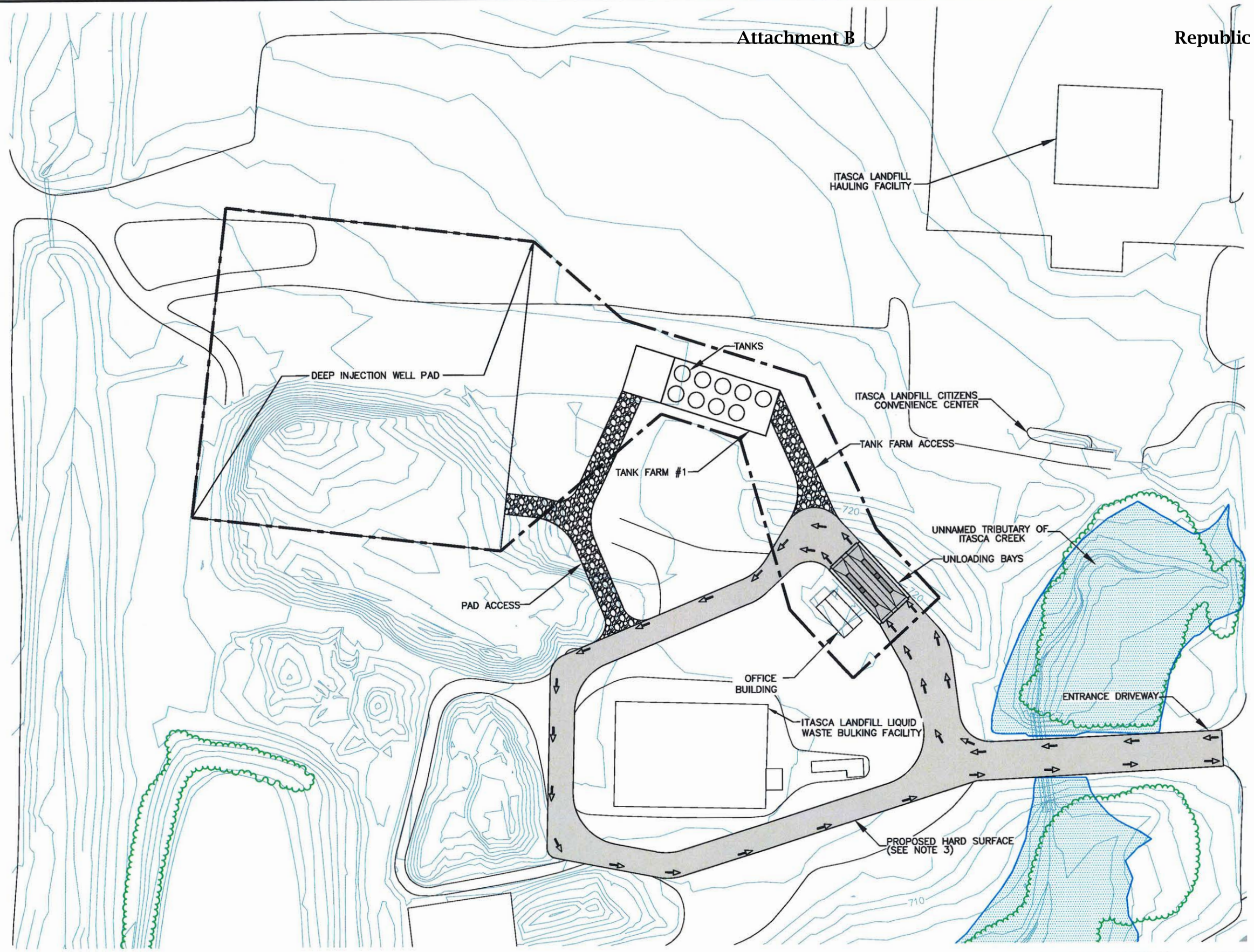
NORTH TEXAS INDUSTRIAL FACILITY
INDUSTRIAL NONHAZARDOUS WASTE PERMIT
SITE PLAN

HILL COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE D-2

O:\0120\084\IWP PERMIT\FIG D-2-Site Plan.dwg, rarrington, 1:2



0 50 100
SCALE IN FEET

LEGEND

- NORTH TEXAS INDUSTRIAL FACILITY PERMIT BOUNDARY
- 720 EXISTING CONTOUR
- LIMITS OF HEAVILY TREED VEGETATION
- 100-YEAR FLOODPLAIN (SEE NOTE 2)
- WASTE TRANSFER VEHICLE TRAFFIC

NOTES:

1. EXISTING CONTOURS PROVIDED BY COOPER AERIAL SURVEYS CO. FROM AERIAL PHOTOGRAPHY, FLOWN 12-04-2018 AND DESIGN CONTOURS OF PHASE 16B/17 PREPARED BY WEAVER CONSULTANTS GROUP ON SEPTEMBER 2018.
2. FLOODPLAIN REPRODUCED FROM MAJOR PERMIT AMENDMENT APPLICATION PREPARED BY WEAVER CONSULTANTS GROUP DATED MAY 2012.
3. DRIVING SURFACES WILL BE GRAVEL, CONCRETE, ASPHALT, RECYCLED CONCRETE, OR OTHER HARD SURFACING
4. FACILITY TRAFFIC FLOW PATTERNS ARE APPROXIMATED ON FIGURE.

STATE OF TEXAS
DAVID E. POE
81734
LICENSED PROFESSIONAL ENGINEER
06/17/21

- [ ] DRAFT
- [x] ISSUED FOR PERMITTING PURPOSES
- [ ] FOR BIDDING PURPOSES ONLY

DATE: 06/2021
FILE: 0120-804-11
CAD: D-3-PROCESSING SITE PLAN.DWG

DRAWN BY: SRF
DESIGN BY: JBP
REVIEWED BY: DP

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
REPUBLIC INDUSTRIAL AND ENERGY SOLUTIONS, LLC

REVISIONS

NO.	DATE	DESCRIPTION

NORTH TEXAS INDUSTRIAL FACILITY
INDUSTRIAL NONHAZARDOUS WASTE PERMIT
PROCESSING SITE PLAN

HILL COUNTY, TEXAS

WWW.WCGRP.COM

FIGURE D-3

COPYRIGHT © 2021 ITASCA LANDFILL TX, LP. ALL RIGHTS RESERVED.

O:\0120\004\INP PERMIT\FIG D-3-Processing Site Plan.dwg, rarrington, 1:2

Attachment C – Permit Application Revision Chronology

Classification	Revision No.[1]	Application Date[2]	Purpose
New Permit	0	June 17, 2021	New ISW permit application received on July 28, 2021
	1	8/9/2021	Administrative NOD Response
	2	12/2/2021	NOD Response with Final Signature Pages Received

[1] Start from Revision 0 using the new permit or permit renewal Application Date, and sequentially increase the revision numbers for each subsequent submittal.
[2] Use the application signature page date as the Application Date.

Attachment D - List of Incorporated Application Materials

The following is a list of the Application for Permit to Store, Process or Dispose of Nonhazardous Industrial Solid Waste elements which are incorporated into all Nonhazardous Industrial Solid Waste permits by reference as per Section I.B.

TCEQ Industrial Nonhazardous Solid Waste Application Form

I. General Information

A. Applicant Information
B. Facility Contact Information
C. Application Location Information
D. Type of Permit for Which Application is Submitted
E. List of Other Permits
F. Facility Information
G. List of Other Sites
H. Wastewater and Stormwater Disposition
I. Waste Management Units (Table I. – Waste Management Unit List)
J. Date of Operation
K. Application Map
L. Information Required to Provide Public Notice
M. Landowner List Information Source
N. TCEQ Core Data Form

II. Facility Management

A. Security
B. Inspection and Maintenance (Table II. – Inspection Schedule)
C. Personnel
D. Equipment
E. Record Keeping
F. Roads

III. Waste Analysis Plan

A. Table III.A. – Waste Management Information
B. Table III.B. - Waste Managed in Permitted Units
C. Table III.C. – Sampling and Analytical Methods
D. Waste Analysis Plan

IV. Engineering Reports

A. Table IV. - Waste Management Unit Information
B. Flow Diagram Description
C. United States Geographical Survey
E. Site Map
F. Aerial Photograph (Reserved)
G. Tanks

V. Geology Report (Reserved)

VI. Ground and Surface Water Protection (Reserved)

VII. Closure and Post-Closure Care Plans

Attachment D - List of Incorporated Application Materials

A. Closure

1. Table VII.A. – Unit Closure
2. Closure Plan
3. Table VII.B. – Unit Closure Cost Estimate
4. Table VII.C. – Permitted Unit Closure Cost Summary
5. Financial Assurance Mechanism
6. Contingent Closure Plan (Reserved)

B. Post Closure Plan (Reserved)

VIII. Confidential Material (Reserved)

Attachment E - List of Permitted Facility Units

Authorized Permitted Units

TCEQ Permit Unit No.[1]	Unit Name	NOR No.[1]	Unit Description	Capacity	Unit Status[2]
T-300	Tank	001	ISW Storage	31,500 gal	Proposed
T-310	Tank	002	ISW Storage	31,500 gal	Proposed
T-320	Tank	003	ISW Storage	31,500 gal	Proposed
T-330	Tank	004	ISW Storage	31,500 gal	Proposed
T-340	Tank	005	ISW Storage	31,500 gal	Proposed
T-350	Tank	006	ISW Storage	31,500 gal	Proposed
T-360	Tank	007	ISW Storage	31,500 gal	Proposed
T-370	Tank	008	ISW Storage	31,500 gal	Proposed
T-260	Product Tank	009	Product Storage	12,500 gal	Proposed
SC-100	Secondary Containment Sump	010	Spill Containment	480 gal	Proposed
UB-100	Unloading Bay	011	Spill Containment	3,680 gal	Proposed
UB-110	Unloading Bay	012	Spill Containment	3,680 gal	Proposed

Historical Permitted Units No Longer Subject to this Permit[4] (N/A)

TCEQ Permit Unit No.[1]	Unit Name	NOR No.[1]	Unit Description[3]	Capacity	Unit Status[2]

[1]Permitted Unit No. and NOR No. cannot be reassigned to new units or used more than once and all units that were in the Attachment D of a previously issued permit must be listed.
[2]Unit Status options: Active, Closed, Inactive (built but not managing waste), Proposed (not yet built), Never Built, Transferred, Post-Closure.
[3]If a unit has been transferred, the applicant should indicate which facility/permit it has been transferred to in the Unit Description column of Table V.A.
[4]The historical units are closed and/or no longer subject to RCRA permit requirements and [is/are] included in this table for informational purposes.

P-100
NON-HAZ. UNLOADING PUMP

P-110
NON-HAZ. UNLOADING PUMP

F-100
MICRON FILTER

F-110
MICRON FILTER

F-120
MICRON FILTER

SK-200
PH NEUTRALIZATION SKID

P-200
METERING PUMP

P-210
METERING PUMP

SK-220
PH NEUTRALIZATION SKID

P-220
METERING PUMP

P-230
METERING PUMP

SK-240
PH NEUTRALIZATION SKID

P-240
METERING PUMP

P-250
METERING PUMP

T-300
LEACHATE INJECTION TANK
500 BBL

T-310
LEACHATE INJECTION TANK
500 BBL

T-320
LEACHATE INJECTION TANK
500 BBL

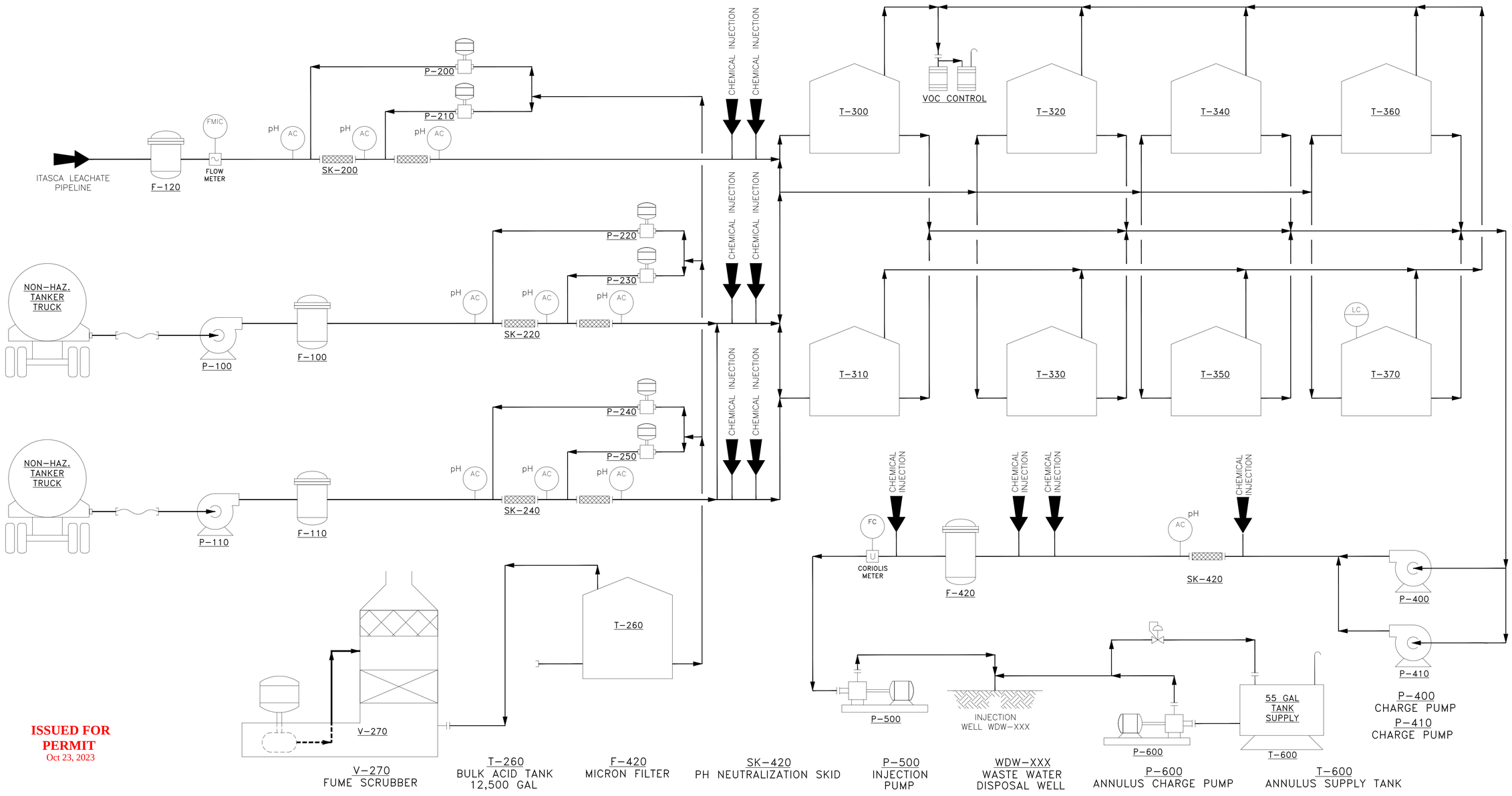
T-330
LEACHATE INJECTION TANK
500 BBL

T-340
LEACHATE INJECTION TANK
500 BBL

T-350
LEACHATE INJECTION TANK
500 BBL

T-360
LEACHATE INJECTION TANK
500 BBL

T-370
LEACHATE INJECTION TANK
500 BBL



V-270
FUME SCRUBBER

T-260
BULK ACID TANK
12,500 GAL

F-420
MICRON FILTER

SK-420
PH NEUTRALIZATION SKID

P-500
INJECTION PUMP

WDW-XXX
WASTE WATER DISPOSAL WELL

P-600
ANNULUS CHARGE PUMP

T-600
ANNULUS SUPPLY TANK

P-400
CHARGE PUMP

P-410
CHARGE PUMP

GENERAL NOTES:

REV.	REVISION	DATE	DRAFT	CHECKED	APP'D.
B	REVISED FOR PERMIT	10/23/23	MJL	–	DAH
A	ISSUED FOR PERMIT	01/13/21	MJL	–	AHN

STATE OF TEXAS
DAVID A. HITDLEBAUGH
108042
LICENSED
PROFESSIONAL ENGINEER
10.23.2023

PELICAN
Energy Consultants, LLC

REPUBLIC SERVICES

TITLE
ITASCA LEACHATE NON HAZARDOUS WASTE INJECTION FACILITY
ITASCA, TEXAS
PROCESS FLOW DIAGRAM

DRAWING APPROVAL

DRAWN BY:	MJL	01/13/21	CHECKED BY:	
DESIGN ENGINEER:			CLIENT APPROVAL:	

CLIENT
REPUBLIC SERVICES

JOB NO. 210106
DWG. NO. 34100

PLOT TIME: October 23, 2023 2:58 PM BY: DAVID HITDLEBAUGH FILE PATH: R:\CLIENT PROJECTS\REPUBLIC SERVICES\ITASCA LEACHATE INLECTION FACILITY\210106\DRAWINGS\30000 MECHANICAL\34000\34100-210106.DWG

P-100
NON-HAZ. UNLOADING PUMP

P-110
NON-HAZ. UNLOADING PUMP

F-100
MICRON FILTER

F-110
MICRON FILTER

F-120
MICRON FILTER

SK-200
PH NEUTRALIZATION SKID
P-200
METERING PUMP
P-210
METERING PUMP

SK-220
PH NEUTRALIZATION SKID
P-220
METERING PUMP
P-230
METERING PUMP

SK-240
PH NEUTRALIZATION SKID
P-240
METERING PUMP
P-250
METERING PUMP

T-300
LEACHATE INJECTION TANK
500 BBL

T-310
LEACHATE INJECTION TANK
500 BBL

T-320
LEACHATE INJECTION TANK
500 BBL

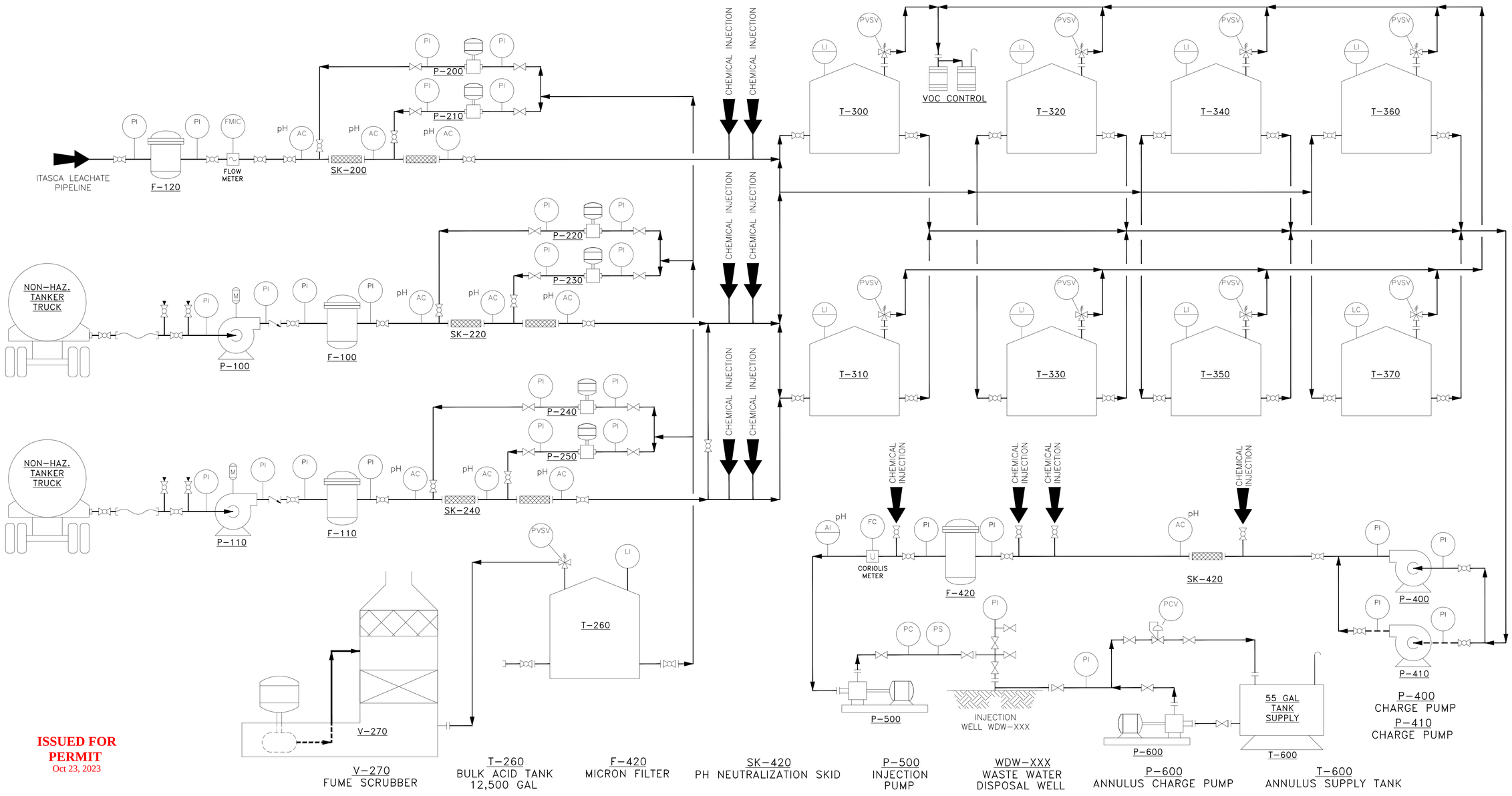
T-330
LEACHATE INJECTION TANK
500 BBL

T-340
LEACHATE INJECTION TANK
500 BBL

T-350
LEACHATE INJECTION TANK
500 BBL

T-360
LEACHATE INJECTION TANK
500 BBL

T-370
LEACHATE INJECTION TANK
500 BBL



ISSUED FOR PERMIT
Oct 23, 2023

V-270
FUME SCRUBBER

T-260
BULK ACID TANK
12,500 GAL

F-420
MICRON FILTER

SK-420
PH NEUTRALIZATION SKID

P-500
INJECTION PUMP

WDW-XXX
WASTE WATER DISPOSAL WELL

P-600
ANNULUS CHARGE PUMP

T-600
ANNULUS SUPPLY TANK

P-400
CHARGE PUMP

P-410
CHARGE PUMP

GENERAL NOTES:

REV.	REVISION	DATE	DRAFT	CHECKED	APP'D.
B	REVISED FOR PERMIT	10/23/23	PEC	–	DAH
A	ISSUED FOR PERMIT	01/13/21	MJL	–	AHN

STATE OF TEXAS
DAVID A. HITDLEBAUGH
108042
LICENSED
PROFESSIONAL ENGINEER
10.23.2023

PELICAN Energy Consultants, LLC

REPUBLIC SERVICES

TITLE
ITASCA LEACHATE NON HAZARDOUS WASTE INJECTION FACILITY
ITASCA, TEXAS
SIMPLE PIPING AND INSTRUMENTATION DIAGRAM

DRAWING APPROVAL

DRAWN BY:	MJL	01/13/21	CHECKED BY:		
DESIGN ENGINEER:			CLIENT APPROVAL:		
CLIENT	REPUBLIC SERVICES			JOB NO. 210106	DWG. NO. 34002

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XIII. CONFIDENTIAL MATERIAL

No confidential material is provided.

XIV. INDEX OF ATTACHMENTS

List and index below all attachments to this application and indicate if included, not included, or not applicable.

Description of Attachment	Section	Attachment	Included	Not Included	Not Applicable
Core Data Form	I.L	A	X		
Public Interest Demonstration	I.M	B	X		
Metes and Bounds Description	I.P.5	C-1	X		
Site Legal Description	I.P.5.	C-2	X		
Facility Boundary	I.P.6	D-1	X		
Topographic Map	I.P.6.	D-2	X		
Locations of Oil and Gad Wells in the Area of Review	I.P.6	D-3	X		
Plain Language Summary	I.Q	E	X		
Public Involvement Plan	I.R	F	X		
Affected Land and Mineral Owners	II.	G	X		
Letter from Railroad Commission	III.	H	X		
Financial Assurance, Liability, and Financial Capability	IV.	I	X		
Radioactive Waste Statement	XI.	J			X

REFERENCES

- Alsalem, Ohood B., Fan, Majie, Zamora, Juan, Xie, Xiangyang, and William, Griffin, R., 2018. Paleozoic sediment dispersal before and during the collision between Laurentia and Gondwana in the Fort Worth Basin, USA: Geosphere, Vol. 14, No. 1, p. 325-342, doi: 10.1130/GES01480.1.
- Austin, Kenneth E., 2020. Hill County: Handbook of Texas Online. Accessed September 2020. Web. https://www.tshaonline.org/handbook/entries/hill-county
- Baker, B., Duffin, G., Flores, R., and Lynch, T., 1990, Evaluation of water resources in part of Central Texas: TWDB Rept. 319, 65 p.
- Budnik, R.T., Ames, J.T., Ridner, D.M., 1990. University of Texas at Austin. Bureau of Economic Geology. Tectonic Map of Texas. Bureau of Economic Geology, University of Texas at Austin.
- Chen, Rongqiang, Xue, Xu ,Park, Jaeyoung, Datta-Gupta, Akhil , King, Michael J., 2020. New insights into the Mechanisms of Seismicity in the Azle Area, North Texas, Geophysics Vol. 85 No.1
- Collins, Edward W., 1994. Abstract: Geology of the Balcones Fault Zone Along the Growth Corridor of San Antonio, Boerne, Wimberley, and New Braunfels, South-Central Texas: AAPG Search and Discovery Article #90983. Accessed August 2020. Web. http://www.searchanddiscovery.com/abstracts/html/1994/gcags/abstracts/ 1452c.htm
- Core Laboratories, Inc, 1972. A Survey of Subsurface Saline Waters of Texas. Texas Water Development Board Report, vol. 157, 113 pp.
- Dennen, Kristin O., and Hackley, Paul C., 2012. Definition of Greater Gulf Basin Lower Cretaceous Shale Gas Assessment Unit, United States Gulf of Mexico Basin Onshore and State Waters: AAPG Search and Discovery Article #10429.
- Earlougher, R. C., Jr., 1977. Advances in Well Test Analysis. SPE Monograph, Volume V, p. 231..
- Eastman, H.S., and Murin, T., 2016. Geologic Characterization of Johnson County, Texas: NETL-TRS-17-2016, NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory, Morgantown, WV, 12 p.
- Evanoff, Bill G., 1976. The Bend Arch: Petroleum Corporation of Texas, Abilene Geological Society Geological Contributions, P. 11.
- Ewing, T.E., 1991. The Tectonic Framework of Texas: ''Text to Accompany'' The Tectonic Map of Texas. Bureau of Economic Geology. University of Texas, Austin.
- Flawn, Peter T., 1959, The Ouachita Structural Belt *in* The Geology of the Ouachita Mountains Symposium: Ardmore Geological Society, p. 20-29.
- George, P.G., Mace, R.E., Petrossian, R., 2011. Aquifers of Texas. Report 380. Texas Water Development Board, Austin, TX. http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R380_AquifersofTexas. pdf
- Hallmark, T.C. 1993. The nature and origin of the Blackland soils. In: M.R. Sharpless and J.C. Yelderman, eds. The Texas Blackland Prairie, land, history, and culture. Pp. 41--47. Baylor Univ. Program for Regional Studies, Waco, TX

— Henry, J. D., 1982, Stratigraphy of the Barnett Shale (Mississippian) and associated reefs in the Northern Fort Worth Basin, in C. A. Martin, ed., Petroleum geology of the Fort Worth Basin and Bend arch area: Dallas Geological Society, 157–178.

— Hentz, Tucker F., 2020. Geology: Handbook of Texas Online. Texas State Historical Association. Accessed August 2020. https://www.tshaonline.org/handbook/entries/geology

— Hill, Kevin B., 2023, Itasca Project, Hill County, Texas Seismic and Geology Report: Hill Geophysical Consulting, Shreveport, Louisiana, 26 p.

— Hornbach, Matthew J., Jones, Madeline, Scales, Monique, DeShon, Heather R., Magnani, M. Beatrice, Frohlich, Cliff, Stump, Brian, Haywood, Chris, Layton, Mary, 2016. Ellenburger wastewater injection and seismicity in North Texas: Physics of the Earth and Planetary Interiors 261. p. 54-68.

— Huffman Jr, A.C., 2003. Middle Pennsylvanian tectonics of the conterminous United States SEPM Special Publication No. 77, ISBN 1-56576-085-9, p. 73-94.

— Hovorka, S. D., and Nance, H. S., 1994, Dynamic depositional and early diagnetic processes in a deep-water shelf setting, Upper Cretaceous Austin Chalk, North Texas: Gulf Coast Association of Geological Societies, Transactions v. 44, p. 269-276.

— Klemt, W.B., Perkins, R.D., and Alvarez, H.J., 1975, Ground-water resources of part of Central Texas, with emphasis on the Antlers and Travis Peak formations: TWDB Rept. 195, 2 vols

— Kuhn, Joshua Keith, 2011, Constructing A Stratigraphic Framework for The Mississippian Barnett Shale: Northern and Central Fort Worth Basin, Texas, Texas Christian University, p. 1 – 58.

— Langley, L., 1999, Updated evaluation of water resources in part of North-Central Texas: Texas Water Development Board Report 349, 69 p.

— Loucks, R. G. and S. C. Ruppel, 2007, Mississippian Barnett Shale: Lithofacies and depositional Setting of a deep-water shale-gas succession in the Fort Worth Basin, Texas: American Association of Petroleum Geologists Bulletin, v. 91, p. 579 – 601.

— Magnani, M. B., Blanpied, M. L., DeShon, H. R., and Hornbach, M. J., 2017, Discriminating between natural vs. induced seismicity from long-term deformation history of intraplate faults: Science Advances, Vol. 3, No. 11, e1701593. https://doi.org/10.1126/sciadv.1701593

— Manger, G. E., 1963, Porosity and bulk density of sedimentary rocks: Contributions to Geochemistry, USGS Bull 1144-E; 1963; pp 60.

— McMillian, M.D., Nwachukwu, C.R., and Rahnema, H., 2016. Geospatial Analysis of Compositional Variations across the Eagle Ford and Barnett Shale Plays: Society of Petroleum Engineers.

— Merrill, M.D., Slucher, E.R., Roberts-Ashby, T.L., Warwick, P.D., Blondes, M.S., Freeman, P.A., Cahan, S.M., Devera, C.A., and Lohr, C.D., 2015. Geologic framework for the national assessment of carbon dioxide storage resources – Permian and Palo Duro Basins and Bend Arch- Fort Worth Basin, Chap. K of Warwick P.D. and Corum, M.D., eds, Geologic framework for the national assessment of carbon dioxide storage resources: U.S. Geological Survey Open-File Report 2012-1024-K, 42 p., http://dx.doi.org/10.3133/ofr20121024K.

— Montgomery, Scott L., Jarvie, Daniel M., Bowker, Kent A., and Pollastro, Richard M., 2005. Mississippian Barnett Shale, Fort Worth Basin, North-Central Texas: Gas-shale play with multi-trillion cubic foot potential: AAPG Bulletin, Vol. 89, No. 2, p. 155-175.

— Mosher, S., Levine, J. and Carlson, W., 2008. Mesoproterozoic plate tectonics: A collisional model for the Grenville-aged orogenic belt in the Llano uplift, Central Texas. Geology, [online] 36(1), p.55. Available at: <https://static1.squarespace.com/static/54b9bb6fe4b07b4a7d145b55/t/56e6dbc727d4bddc106e525e/1457970119565/Mosher-Llano.pdf> [Accessed 1 September 2020].

— Muehlberger, W.R., 1965. Late Paleozoic movement along the Texas lineament. Transactions of the New York Academy of Sciences 27 (4), 385–392, Series II.

— Nordstrom, P.L., 1982, Occurrence, availability, and chemical quality of ground water in the Cretaceous aquifer of North-Central Texas: Texas Water Development Board Report 269, 61 p.

— Pollastro, Richard M., Jarvie, Daniel M., Hill, Ronald J., Adams, Craig W., 2007. Geologic framework of the Mississippian Barnett Shale, Barnett-Paleozoic total petroleum system, Bend Arch- Fort Worth Basin, Texas: AAPG Bulletin Vol. 91, No. 4, p. 405-436.

— Poole, Forrest G., Perry, William J., Madrid, Raul J., and Amaya-Martinez, Ricardoi, 2005. Tectonic synthesis of the Ouachita-Marathon-Sonora orogenic margin of southern Laurentia: Stratigraphic and structural implications for timing of deformational events and plate-tectonic model (Abstract): Special Paper 393, The Mojave-Sonora Magashear Hypothesis: Development, Assessment, and Alternatives, p. 543-596. Accessed August 2020. Web. https://www.researchgate.net/publication/279403760_Tectonic_synthesis_of_the_Ouachita-Marathon-Sonora_orogenic_margin_of_southern_Laurentia_Stratigraphic_and_structural_implications_for_timing_of_deformational_events_and_plate-tectonic_model

— Quinones, A.Q., DeShon, H.R., Magnani, M.B. and Frohlich, C., 2018. Stress Orientations in the Fort Worth Basin, Texas, Determined from Earthquake Focal Mechanisms, Bulletin of the Seismological Society of America.Web.https://www.beg.utexas.edu/files/texnetcisr/pubs/Quinones%20et%20al%202018%20FWB%20Focal%20Mechs%20SSA.pdf

— Reaser, Donald F., 1961. Balcones Fault System: Its Northeast Extent: AAPG Bulletin, Vol. 45 (10), P. 1759-1762. Accessed August 2020. Web. https://doi.org/10.1306/BC743729-16BE-11D7-8645000102C1865D

— Rose, Peter R., 2016. Late Cretaceous and Tertiary Burial History, Central Texas: Gulf Coast Association of Geological Societies (GCAGS Journal), Vol. 5, p. 141-179.

— Rozendal, R.A., Erskine, W.S., 1971. Deep test in Ouachita structural belt of Central Texas. AAPG Bulletin 55 (11), 2008–2017.

— Smye, Katie M., Lemons, Casee R., Eastwood, Ray, McDaid, Guinevere, Hennings, Peter H., 2019. Stratigraphic architecture and petrophysical characterization of formations for deep disposal in the Fort Worth Basin, Texas: University of Texas at Austin, Bureau of Economic Geology, Austin, Texas, USA. Interpretation, Vol. 7, No. 4, p. SL1-SL17.

— Texas Administrative Code (TAC),

— Thomas, Jimmy D., 2003. Integrating Synsedimentary Tectonics with Sequence Stratigraphy to Understand the Development of the Fort Worth Basin: AAPG Search and Discovery Article #90023, Ruidoso, New Mexico.

— Thompson, D.M., 1982. Atoka Group (Lower-Middle Pennsylvanian), Northern Fort Worth Basin Texas: Terrigenous Depositional Systems, Diagenesis, and Reservoir Distribution and Quality (Abstract): The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 125, p. 62. DOI 10.23867/RI0125D Web.

http://www.beg.utexas.edu/publications/atoka-group-lower-middle-pennsylvanian-Northern-fort-worth-basin-texas-terrigenous

- Trice, E.L., 1982. Depositional History of Strawn Group (Pennsylvanian), Fort Worth Foreland Basin, Colorado River Valley, Central Texas: Abstract: AAPG Bulletin Vol. 66, Issue 5, p. 637.
- Turner, G. I., 1957. Paleozoic stratigraphy of the Fort Worth Basin. In *Abilene and Fort Worth Geological Societies Joint Field Trip Guidebook;* Bell, W. C., Ed.; p 57–77.
- United States Geological Survey, 2023, Earthquake Hazards Program: Earthquake Catalog. Retrieved from https://earthquake.usgs.gov/earthquakes/search/
- Walcott, C.D., 1901. Twenty-First Annual report of the Director of the United States Geological Survey, 1899-1900: Part VII - Texas: USGS Report.21, 666p.
- Ward, Boerne, 2006. Geologic History of South-Central Texas: Geologic History as it Relates to Modern Vegetation Patterns of South-Central Texas. Web.
- Winslow, A.G., and Kister, L. R., Jr., 1956, Saline water resources of Texas: U.S. Geological Survey Water-Supply Paper 1365, 105 p.